United States Court of Appeals

for the

District of Columbia Circuit

TRANSCRIPT OF RECORD

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Court of Appeals of the District of Columbia

OCTOBER TERM, 1932

No. 5839

299

VREELAND CORPORATION, APPELLANT,

vs.

THOMAS E. ROBERTSON, AS COMMISSIONER OF PATENTS.

APPEAL FROM THE SUPREME COURT OF THE DISTRICT OF COLUMBIA.

FILED NOVEMBER 2, 1932.

PRINTED DECEMBER 16, 1932.

Court of Appeals of the District of Columbia

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No. 5839

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JUDD & DETWEILER (INC.), PRINTERS, WASHINGTON, D. C., NOVEMBER 23, 1932.

Court of Appeals of the District of Columbia

No. 5839.

Vreeland Corporation, Appellant,

vs.

Thomas E. Robertson, as Commissioner, &c.

---

a Supreme Court of the District of Columbia.

In Equity.

No. 51457.

Vreeland Corporation, Plaintiff,

vs.

Thomas E. Robertson, as Commissioner of Patents, Defendant.

United States of America,
District of Columbia, ss:

Be it remembered, That in the Supreme Court of the District of Columbia, at the City of Washington, in said District, at the times hereinafter mentioned, the following papers were filed and proceedings had in the above-entitled cause, to wit:

1 *Bill.*

(To Enforce Issuance of Patent.)

Filed May 22, 1930.

Supreme Court of the District of Columbia.

In Equity.

No. 51457.

Vreeland Corporation, Plaintiff,

vs.

Thomas E. Robertson, as Commissioner of Patents, Defendant.

Under Section 4915 R. S.

The plaintiff, Vreeland Corporation, complaining of the defendant, says:

First. That plaintiff, Vreeland Corporation, is a corporation duly organized and existing under the laws of the State of New Jersey, and has its principal office at #1 Newark Avenue, in the City of Hoboken, in the State of New Jersey, and is an inhabitant of said State of New Jersey; and that the defendant, Thomas E. Robertson, Commissioner of Patents, in his official capacity as Commissioner of Patents is domiciled in the District of Columbia.

Second. That the jurisdiction of this Court over this cause depends upon Section 4915 of the Revised Statutes of the United States, this suit being brought to secure an adjudication that plaintiff is entitled to receive a patent for the invention hereinafter referred to, and that the defendant be authorized to issue such patent.

Third. That Frederick K. Vreeland being, within the meaning of the statutes of the United States then in force, the original, sole and first inventor of certain improvements in Amplification of Electric Current Waves, and being entitled to a patent thereon under the provisions of said statutes, duly filed in the United States Patent Office on November 21, 1923, an application for Let-
2 ters Patent for said invention, which application is
serially No. 675,995.

That on or about March 5, 1925, the said Frederick K. Vreeland did execute and deliver to plaintiff, Vreeland Corporation, a written assignment of the entire right, title and interest in and to said invention and application for patent Serial No. 675,995, directing the issue of the Letters Patent thereon to said Vreeland Corporation as sole assignee, which said assignment was recorded in the United States Patent Office March 13, 1925 in Liber S. 123, Page 375, of Transfers of Patents. Said Vreeland Corporation thereby became, and has ever since continued to be, and now is, the sole owner thereof.

That said application for patent was duly examined in the Patent Office, and after certain proceedings thereon was finally rejected on or about January 27, 1928; that from said rejection by the Examiner appeal was taken to the Board of Appeals of the Patent Office who, on November 27, 1929, affirmed the decision of the Examiner, the decision of the Board of Appeals being based upon the showing of the prior art made in the United States patents of Lowell et al., No. 1,455,141, May 15, 1923, and DeForest, No. 1,314,250, August 26, 1919.

Fourth. Plaintiff avers on information and belief that neither of said patents contains a disclosure either of the purpose or of the mode of operation of the invention covered by said application No. 675,995 or anticipates such invention.

Wherefore the plaintiff prays that the said Frederick K. Vreeland be adjudged entitled, according to law, to receive a patent for the invention set forth in the said application No. 675,995 and in the claims thereof as in a certified copy of said application and the proceedings thereon to be filed as your Honors shall direct, will more fully and at large appear and that the defendant, as Commissioner of Patents, be authorized to issue such 3 patent to plaintiff, Vreeland Corporation, as sole assignee of said invention.

And that the plaintiff have a writ of subpœna ad respondendum of the United States of America, directed to the said Thomas E. Robertson, as Commissioner of Patents, commanding him on a day certain therein to be named, to appear and answer this bill of complaint, but not under oath, which is hereby waived, and to abide by and perform all and singular such orders and decrees in the premises as to this Court shall seem proper and conformable to the principles of equity.

And that the plaintiff have such other and further relief as may be just and proper.

VREELAND CORPORATION,
By FREDERICK K. VREELAND,
President.

WILLIAM B. GREELEY,
Plaintiff's Attorney,
38 *Park Row, New York, N. Y.*

ARTHUR P. GREELEY,
Plaintiff's Attorney,
Washington Loan & Trust Bldg.,
Washington, D. C.

STATE OF NEW YORK,
County of New York, ss:

On this 21st day of May, 1930 before me personally appeared Frederick K. Vreeland, President of Vreeland Corporation, the plaintiff above named, who being by me first duly sworn, deposes and says that he has read the foregoing Complaint and knows the contents thereof, and that the same is true of his own knowledge, except as to the matters therein stated on information and belief, and that as to those matters he believes it to be true. Deponent further says that the reason why this verification is not made by the party and is made by him is that the defendant is a foreign corporation.

[SEAL.] HAROLD A. CARTER,
Notary Public, New York County.

N. Y. Co. Cl'k No. 271, Reg. No. 1C179.
Commission expires March 30, 1931.

4 *Answer to Bill.*

Filed June 6, 1930.

* * * * * * *

To the Honorable the Judges of the Supreme Court of the District of Columbia:

1. Defendant answering the Bill of Complaint admits for the purpose of this suit the allegations of the first paragraph.

2. Defendant admits the jurisdiction under Section 4915 R. S. (35 U. S. C. A. 63).

3. Defendant admits that Frederick K. Vreeland, filed an application for patent on November 21, 1923, to which was given Serial No. 675,995, in which he made the allegations specified in the third paragraph. Defendant admits that the application was assigned to plaintiff, as stated, and that the application was examined in the Patent Office and was rejected by the examiner, which rejection was affirmed by the Board of Appeals, the following patents being relied upon, viz:

Lowell et al., 1,455,141, May 15, 1923,
De Forest, 1,314,250, Aug. 26, 1919.

Profert of said patents is hereby made.

4. Defendant denies that the claims are patentable to plaintiff in view of said patents No. 1,455,141 and No. 1,314,250, as more fully appears from the decision of the Board of Appeals, profert of which is hereby made.

Further answering, defendant denies each and every allegation of the Bill of Complaint not herein specifically and sufficiently denied or admitted, and prays that plaintiff's Bill of Complaint be dismissed.

5 Wherefore defendant, having fully answered the Bill of Complaint, denies that plaintiff is entitled to the relief demanded or any part thereof and prays that he be hence dismissed with all costs and expenses of the proceedings against the plaintiff as required by Section 4915 R. S.

THOMAS E. ROBERTSON,
Commissioner of Patents, Defendant.

T. A. HOSTETLER,
Solicitor of the U. S. Patent Office,
Attorney for Defendant.

District of Columbia,
City of Washington, ss:

I, Thomas E. Robertson, Commissioner of Patents, depose and say that I have read the above answer by me subscribed and know the contents thereof, and that the statements of facts therein made as upon personal knowledge are true, and those made upon information and belief I believe to be true.

THOMAS E. ROBERTSON,
Commissioner of Patents.

Subscribed and sworn to before me this 6th day of June, 1930.

[SEAL.] ALBERT W. KAISER,
Notary Public, D. C.

My commission expires April 6, 1933.

Findings of Fact and Conclusions of Law.

Filed July 1, 1932.

* * * * * * *

Findings of Fact.

6 1. Frederick K. Vreeland, on November 21, 1923, filed the application for letters patent involved herein to which application Serial No. 675,995 was given.

2. The said application discloses an amplifier comprising among other features a grid circuit having therein a condenser between the grid and the filament.

3. After due proceedings the examiner rejected all of the claims standing in the application on the following patents:

De Forest, 1,314,250, Aug. 26, 1919,
Lowell et al., 1,455,141, May 15, 1923.

4. Appeal was taken to the Board of Appeals, which Board of Appeals on November 27, 1929, rendered a decision affirming the decision of the examiner.

5. The patent to De Forest discloses in Fig. 2 a grid circuit leading from the audion to the filament, in which grid circuit is included a condenser shown in dotted lines and marked 30.

6. The patent to Lowell et al. discloses in Fig. 2 a grid circuit leading from the audion marked 13 to the filament, in which grid circuit is included a condenser marked 12.

Conclusions of Law.

1. Plaintiff is not entitled to the allowance of the claims pending in his application as they do not distinguish patentably from the De Forest patent as shown in Fig. 2 in the grid circuit in which the condenser 30 is located and in the parts operatively associated with said grid circuit.

2. Plaintiff is not entitled to the allowance of the claims pending in the application as they do not distinguish patentably from the Lowell et al. patent as shown in Fig. 2 in the grid circuit in which the condenser 12 is located and in the parts operatively associated with said grid circuits.

7 3. The claims are unpatentable to plaintiff over the disclosure of the De Forest and the Lowell et al. patents as applied in the statement of the Examiner and in the decision of the Board of Appeals.

4. Plaintiff is not entitled to a Decree under Section 4915 R. S. for the claims pending in the Vreeland application and the Bill of Complaint will be dismissed.

July 1st, 1932.

DANIEL W. O'DONOGHUE,
Justice.

Copy received this 29th day of June, 1932.

A. P. GREELEY,
For Plaintiff.

Final Decree.

Filed July 1, 1932.

* * * * * * *

This cause having come on to be heard and having been tried in open court and argued by counsel for the respective parties upon the pleadings and proofs adduced and submitted to the Court,

It is adjudged, ordered, and decreed, this 1st day of July, 1932, that the Bill of Complaint in this case be, and the same hereby is dismissed with costs against the plaintiff.

DANIEL W. O'DONOGHUE,
Justice.

8 *Notice of Appeal, &c.*

Filed July 20, 1932.

* * * * * * *

The Clerk of said Court will note an appeal on behalf of the plaintiff in the above entitled cause from the decree entered therein on the first day of July, 1932.

A. P. GREELEY,
Attorney for Plaintiff.

July —, 1932.

Order Fixing Bond.

It appearing to the Court that the plaintiff has noted an appeal from the decree of July 1, 1932, it is, this 20th day of July, 1932, ordered:

That the bond on appeal be, and the same is hereby fixed in the sum of One Hundred Dollars ($100.00) or in lieu thereof plaintiff deposit with the Clerk the sum of Fifty Dollars ($50.00) in cash.

O. R. LUHRING,
Justice.

Citation.

Issued July 20, 1932.

* * * * * * *

The President of the United States of America to Thomas E. Robertson, Commissioner of Patents, Greeting:

You are hereby cited and admonished to be and appear at a Court of Appeals of the District of Columbia, upon the

docketing the cause therein, under and as directed by the Rules of said Court, pursuant to an Appeal noted in
9 the Supreme Court of the District of Columbia, on the 20th day of July, 1932, wherein The Vreeland Corporation is Appellant, and you are Appellee, to show cause, if any there be, why the Decree rendered against the said Appellant, should not be corrected, and why speedy justice should not be done to the parties in that behalf.

Witness the Honorable Alfred A. Wheat, Chief Justice of the Supreme Court of the District of Columbia, this 20th day of July, in the year of our Lord one thousand nine hundred and thirty-two.

[SEAL.] FRANK E. CUNNINGHAM,
Clerk,
By GEORGE A. WATTS,
Assistant Clerk.

Service of the above Citation accepted this 21st day of July, 1932.

T. A. HOSTETLER,
Attorney for Appellee.

Memorandum.

July 20, 1932.—$50 deposited in lieu of bond on appeal.

Extension of Time for Filing Statement of Evidence.

Filed July 20, 1932.

* * * * * * *

It is hereby stipulated and agreed by and between counsel for the respective parties herein that, subject to the approval of the court, the time for filing the assign-
10 ment of error and statement of evidence on plaintiff's appeal be extended to sixty days.

A. P. GREELEY,
For Plaintiff.
T. A. HOSTETLER,
For Defendant.

Approved and so ordered.

O. R. LUHRING,
Justice.

Memorandum.

September 26, 1932.—Statement of Evidence filed.

Assignment of Error.

Filed September 26, 1932.

* * * * * * *

It is respectfully submitted:

First. That the court erred in finding as a conclusion of law that the claims pending in plaintiff's application do not distinguish patentably from the DeForest patent #1,314,259, Aug. 26, 1919.

Second. That the court erred in finding as a conclusion of law that the claims pending in plaintiff's application do not distinguish patentably from the Lowell et al. patent #1,455,141, May 15, 1913.

Third. That the court erred in finding as a conclusion of law that the claims are unpatentable to plaintiff over the disclosure of the DeForest and the Lowell et al. patents, as applied in the statement of the Examiner and in the decision of the Board of Appeals.

Fourth. That the court erred in finding as a
11 conclusion of law that plaintiff is not entitled to the
allowance of the claims pending in his application.

Fifth. That the court erred in finding as a conclusion of law that the plaintiff is not entitled to a decree under Section 4915 R. S.

Sixth. That the court erred in dismissing plaintiff's bill of complaint.

Wherefore plaintiff prays that the said decision be reversed and that the said court may be directed to enter a decree in accordance with prayer of the bill of complaint.

A. P. GREELEY,
Attorney for Plaintiff.

Designation of Record.

Filed September 26, 1932.

* * * * * * *

Plaintiff appellant, by its attorney, designates the following to constitute the transcript of record in the above entitled cause.

1. Bill of complaint.

2. Answer.
3. Findings of fact and conclusions of law.
4. Decree of July 1, 1932.
5. Notation of appeal.
6. Citation.
7. Order fixing bond.
8. Memorandum of deposit.
9. All exhibits mentioned in and referred to in the Statement of Evidence. See Statement of Evidence.

12 10. Statement of evidence.
11. Assignments of error.
12. This designation.

A. P. GREELEY,
Attorney for Plaintiff.

13 Supreme Court of the District of Columbia.

UNITED STATES OF AMERICA,
District of Columbia, ss:

I, Frank E. Cunningham, Clerk of the Supreme Court of the District of Columbia, hereby certify the foregoing pages numbered from 1 to 12, both inclusive, to be a true and correct transcript of the record, according to directions of counsel herein filed, copy of which is made part of this transcript, in cause No. 51457 in Equity, wherein Vreeland Corporation is Plaintiff and Thomas E. Robertson, as Commissioner of Patents, is Defendant, as the same remains upon the files and of record in said Court.

In testimony whereof I hereunto subscribe my name and affix the seal of said Court, at the City of Washington, in said District, this 27th day of October, 1932.

[Seal Supreme Court of the District of Columbia.]

FRANK E. CUNNINGHAM,
Clerk.

14 In the Court of Appeals of the District of Columbia.

VREELAND CORPORATION, Appellant,

vs.

THOMAS E. ROBERTSON, Commissioner of Patents, Appellee.

Stipulation of Record.

It is hereby agreed that the accompanying nar-ative of the testimony of Dr. Lee DeForest, together with the certified copy of the file wrapper and contents of the application of Frederick K. Vreeland, Serial No. 675,995, and the printed copies of U. S. patents 1,314,250 to DeForest, 1,231,764 to Lowenstein, and 1,455,141 to Lowell et al., shall constitute the statement of evidence herein.

A. P. GREELEY,
Attorney for Appellant.
T. A. HOSTETLER,
Attorney for Appellee.

November 1, 1932.

Approved.

DANIEL W. O'DONOGHUE,
Justice.

15 In the Supreme Court of the District of Columbia.

In Equity.

No. 51457.

VREELAND CORPORATION, Plaintiff,

vs.

THOMAS E. ROBERTSON, Commissioner of Patents,
Defendant.

On Appeal to the Court of Appeals for the District of Columbia.

Filed Sep. 26, 1932.

Deposition of Dr. Lee DeForest, taken *de bene esse* pursuant to notice to defendant on Wednesday, February 3, 1932, at the office of Darby & Darby, 405 Lexington Avenue, New York City, before Rose A. Batterman, notary public, and duly certified under seal by said notary.

Said **Dr. DeForest**, being first duly sworn, testifies as follows:

That he is of mature age, resides in Los Angeles, California, is an inventor and research engineer. He is the inventor of the three electrode audion, cascade amplifier and audion relay and repeater, the regenerative or feed-

back circuit, and the audion oscillator universally used in the radio communication and allied arts. That he began working on problems concerning wireless connections in 1900 and was exclusively engaged on such problems until 1919, and since that year has been active in radio matters of invention and those relating to talking pictures, television research and similar subjects, has received first prize for his work in radio at the World's exposition at St. Louis in 1904 and at San Francisco in 1915; has been awarded the medal of honor of the Institute of Radio En-
gineers; the Elliot Creson medal of the Franklin
16 Institute for the audion; the John Scott medal of
the City of Philadelphia for the same; the Cross
of the Legion of Honor from France; the honorary degrees of Doctor of Science from Syracuse and Yale Universities. That ever since the invention of the audion in 1906 he has continued its use and development of improvements in its form and in new applications of it, and has contributed to many of the various uses of the audion, that the use of the audion has been extended to every branch of electric communication, whether by wire or wireless. It is universally used throughout the entire industry of talking pictures, in traffic and elevator control, in railway signalling, and in countless fields of industry where control or counting of operations in involved.

Dr. DeForest testified that he had studied very carefully the Vreeland application, Serial No. 675,995, with particular reference to claims 1 to 4 and 9 to 12 thereof. That this application of Vreeland's discloses a novel method of obtaining and maintaining on the grid or control element of a vacuum tube or audion, a negative grid potention whereby the operation of the device as an amplifier functions along the straight line portion of the characteristic curve of the audion.

That it has been recognized for many years ever since the issuance of the patent to Lowenstein, #1,231,764, July 5, 1917, commonly known as the grid or "C" Bias patent, that in order to obtain undistorted amplification from an
audion or three electrode vacuum tube it is essential
17 that a constant negative potential be applied to the
grid electrode relative to the potential of the fila-
ment whereby the operation of the devise as an amplifier

is confined to the straight line portion of its characteristic curve.

This Lowenstein patent covers a battery for "impressing upon said modulating device (meaning the grid of an audion tube) a potential more negative than that of a cathode." The patentee shows in the figure of this patent a battery connected between one terminal of the filament thereof and the grid or control electrode and describes that the battery should be so poled that the potential of the grid is negative relative to the filament.

The origin of the name "grid" or "C" bias patent" arose as follows: In my (DeForest's) original three electrode audion patent #879,532, I showed a battery for lighting a filament which was labeled in the patent drawing "A". The battery that as connected in the plate filament circuit was labeled "B" on the drawing. This terminology was adopted by the art and is still employed today to designate the filament battery and the plate circuit battery as "A" and "B" batteries respectively. Apparently, when a battery was included in a grid filament circuit for the sake of consistency the art adopted the next consecutive letter in the alphabet to designate said battery and to avoid confusion between what was then well known in the art as the "A" and "B" batteries, respectively.

Stating the importance that the negative or "C" bias battery has been to the industry and the position the
18 Lowenstein patent therefore has been accorded in the industry, the witness said:

"The Lowenstein patent pointed out the advantages of biasing the grid electrode negatively relative to the filament and since that date it has been universally recognized throughout the radio industry, and particularly in the telephone art, that where undistorted amplification is required between the input and output circuits of an audion, it is essential to bias the grid negatively relative- to the filament in order that the operation of the device be confined to the straight line part of the characteristic curve. The radio and telephone industries have universally used the "C" battery, or its equivalent, for example in the form of a potentiometer, for obtaining the proper negative grid potential in all amplifiers. As a result of this situation the Lowenstein patent has proved to be one of the most important from a monopolistic standpoint in these industries. The patent has been sustained by the United States Federal Court, Southern District of New York, a number of years ago and, so far as I know, has been generally acquiesced in in the art.

This situation has caused investigation and research in the endeavor to find some other way of securing efficient operation of an audion amplifier without distortion and without the use of a "C" battery. Many intensive efforts by various radio engineers and organizations have been directed towards finding a means of obtaining perfect
19 amplification with the audion without biasing the
grid electrode as taught by Lowenstein. For example, certain amplifiers have been designed using double the number of tubes necessary if the grid bias is used, with a complicated circuit whereby it was proposed to obtain equally good amplification results without the use of the "C" battery. Others have attempted to avoid the patent to Lowenstein by means of specially constructed tubes so designed that either no voltage or an actual positive grid voltage can be used on the grid. No satisfactory, practical results to my knowledge have been obtained by the use of such devices.

An invention which would enable the use of a negative bias on the gird electrode and an audion amplifier without the employment of a "C" battery or equivalent would unquestionably be of very great commercial value in the industry and would free independent operation from monopolistic control made possible by the Lowenstein patent.

The invention disclosed in the Vreeland application, as claimed in Claims 1 to 4 and 9 to 14, inclusive, enables a negative potential to be maintained on a grid electrode of an audion amplifier without the employment of a battery or equiv*ela*nt means for impressing such negative potential on the grid. This is the exact effect of the Vreeland invention. In addition the Vreeland invention goes further in that it affords means for automatically and continuously applying to the grid electrode a mean or average negative potential which varies from time to time in
20 keeping with the intensity of the voltage of the in-
coming signal currents and quite independent of the amount of positive voltage which may be applied to the plate electrode of the audion. This latter is a real and

very practical advantage as heretofore where the "C" battery is employed it has been essential to determine the voltage of the latter within quite narrow limits, depending upon the plate potential. In other words, if the plate potential were considerably increased it was necessary to increase the negative voltage of the "C" battery applied to the grid. If the plate voltage were reduced, which happens frequently in radio receivers as the dry battery in the plate circuit deteriorates, it is necessary to correspondingly reduce the applied "C" battery voltage. Otherwise great and frequently annoying distortion of signals results, an effect which has doubtless been observed by hundreds of thousands of users of radio receivers.

In terms of practical operation this means that whenever these conditions occur it is essential for the operator in charge of the device to go to more or less trouble to readjust the applied grid voltage. It frequently happens that where high power amplifiers or modulators are involved this proper adjustment of the "C" voltage in harmony with the applied "B" voltage is not an easy matter where high voltages are involved. The Vreeland invention, however, applies equally well to small power receiving or amplifying tubes and to high power amplifiers, modulators, or oscillator tubes where high voltages are involved
and where the proper maintenance of the "C"
21 voltage as the "B" voltage may change is frequently
necessary and by no means easy to accomplish.

Witness states that he is aware of another very important advantage inherent in the Vreeland invention over that of Lowenstein. I refer to the frequently observed blasting or great distortion of amplified signal due to overload of the device occasioned by reception of very strong signals. It frequently happens, for example, in radio receiver amplifiers, that strong local stations may be brought in which cause great overload and resultant distortion of sound from the loud speaker. To obviate this annoying occurrance by means of the Lowenstein invention it would be necessary for the operator to be frequently or continuously varying the applied grid voltage to compensate for the unusual strength of signals received. This compensating arrangement is very seldom practical or applied, and radio reception frequently suffers greatly from the lack thereof. Whereas, by the Vreeland invention, the mean or

average grid voltag- is automatically shifted in proportion to the intensity of the incoming signal, as clearly pointed out in Vreeland's specification, so that the above described overload and distortion is impossible. By the Vreeland invention if too strong signals are received the audion amplifier merely checks or ceases momentarily to function. The signals heard from the loud speaker, instead of becoming distressingly loud and raucous merely tail off momentarily into silence and then automatically resume their normal strength when the signal action is restored to its usual intensity. This makes the reception of broadcast
22 programs much more pleasant, especially where one is listening to signals from powerful nearby radio transmitters.

Witness states that he was not cognizant of the ability to accomplish the above described results acomplished by the Vreeland invention by means of a condenser included in a grid circuit of an audion until he read Vreeland's specification.

Attention being called to patent #1,314,250, granted to him August 26, 1919, on an application filed Sept. 8, 1914, a division of application Serial No. 775,529, filed June 24, 1913, witness states that there is nothing inconsistent with the disclosure in that patent and his statement just above made.

"Although the diagrams of this patent show open circuited grid connections, or a condenser indicated as being inserted in the grid filament connection, the devices which I used at the time I applied for this patent and long thereafter were not such as to effect the automatic stabil-ation of the average grid bias as described by Vreeland. I was using at this time audion tubes in cascade circuit for amplifying audio frequencies, and the condensers that I employed were invariably so-called "telephone condensers" having the usual capacity of from 1 to 4 m. f., capacities which were altogether too large to permit my observation of the effect which Vreeland later discovered when he employed condensers of an entirely different order of magnitude. Moreover, the leakage resistance of the con-
23 densers which I employed was very much lower than the resistance which he described in his patent application. Where the condenser is not used I had the

equivalent effect of a very large condenser because the transformers which I was using were all straight iron core cylindrical form without any special means provided for adequate insulation between primary and secondary windings. Their inductance was of relatively large order, many turns of both primary and secondary windings, and the capacity therebetween was relatively large and the insulation resistance small compared with what is now in modern amplification circuits considered essential.''

The condensers which witness used in his work which formed the basis of his patent were not capable of operating in the manner or for the purpose specified in the Vreeland application in the circuits disclosed in his (witness's), for the reason that these condensers were usually one hundred to several hundred times too great in capacity.

Witness being asked whether in connection with the work he had with the circuits disclosed in his patent, both prior to and subsequent to the issuance of the patent, he had ever been cognizant of the desirability of using condensers of the type and character specified in the Vreeland application for the purpose specified in the Vreeland specification, stated:

''No, I did not discover and did not realize that the effect described in Vreeland's application could be obtained by
the means he shows. I was not alone in this igno-
24 rance. I might say the entire radio profession had
been, since the issuance of the Lowenstein patent at least, interested in discovering some practical and simple means for obtaining straight line amplification without the use of a separate or distinct source of electromotive force applied to the grid and, notwithstanding the diagrams of my patent above referred to, no one apparently prior to Vreeland was aware of this important practical possibility.''

Witness states that through his knowledge of the radio industry there is no doubt in his mind as to the operability of the Vreeland circuit. He states that though he has not himself had opportunity since studying the Vreeland application to make the experiments himself, he recognizes that the theory of this phenomena as described in the Vreeland patent application is unassailable, and that, with the proper values of capacity and resistance in the grid circuit the effect which Vreeland has discovered can be obtained.

Witness states that the Vreeland arrangement is by far the simplest, the least complicated means which has ever come to his attention for obtaining a negative grid bias.

Witness states that he is not financially interested in the Vreeland application or in any of the Vreeland companies; that he has not been offered or promised any remuneration for the testimony which he has given in this matter, and that the considerations prompting him to give his evidence in this case are merely considerations of friendship
25 for Dr. Vreeland as he does not wish to have patents of his interpreted as disclosing inventions which he had not actually made.

26 390.

Department of Commerce, United States Patent Office.

To all persons to whom these presents shall come, Greeting:

This is to certify that the annexed is a true copy from the records of this office of the Petition, Specification, Oath and Drawing, as originally filed, and Papers 6 and 8, in the matter of the Pending Application of Frederick K. Vreeland, filed November 21, 1923, Serial Number 675,995, for Improvement in Amplification of Electric Current Waves.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed, at the City of Washington, this twenty-first day of July, in the year of our Lord one thousand nine hundred and thirty-two and of the Independence of the United States of America the one hundred and fifty-seventh.

[Seal Patent Office, United States of America.]

THOMAS E. ROBERTSON,
Commissioner of Patents.

Attest:
D. E. WILSON,
Chief of Division.

27 [Stamp:] Mail Room, U. S. Patent Office. Nov. 21, 1923.

Petition.

To the Commissioner of Patents:

Your petitioner, Frederick K. Vreeland, a citizen of the United States, residing at and whose Post Office address is 228 Orange Road, Montclair, Essex County, in the State of New Jersey, prays that Letters Patent of the United States may be granted to him for new and useful improvements in amplification of electric current waves set forth in the annexed specification, and he hereby appoints William A. Redding, William B. Greeley, Ambrose L. O'Shea and Worthington Campbell, constituting the firm of Redding, Greeley, O'Shea & Campbell, of No. 38 Park Row, in the Borough of Manhattan of the City of New York, in the State of New York (registration No. 897), his attorneys, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith.

FREDERICK K. VREELAND.

[Canceled 25-cent internal-revenue stamp.]

28

Specification.

To all whom it may concern:

Be it known that I, Frederick K. Vreeland, a citizen of the United States, residing in Montclair, Essex County, State of New Jersey, have invented certain new and useful improvements in amplification of electric current waves, of which the following is a specification, reference being had to the accompanying drawings forming a part hereof.

The invention herein described relates to the amplification of electric current waves and particularly to the construction and method of operation of thermionic amplifiers.

The object of the invention is to simplify the construction and operation of such amplifiers and at the same time improve the fidelity of reproduction of the original wave form in the amplified current.

In the operation of a thermionic amplifier, the wave form of the output current or electromotive force is determined, not only by the wave form of the input electromotive force, but also by the operating characteristic of the amplifier tube. In order that the output wave may be a faithful reproduction of the input wave the amplifier tube should be operated on the straight portion of its characteristic curve, so that the variations of output current are directly proportional to the variations of the input electromotive force. Various devices have been proposed for insuring the operation of the tube on the straight portion of its characteristic.

In accordance with the present invention I secure this result by a device of great simplicity and an improved method of operation which insure faithful reproduction of the wave form for all current waves which do not exceed a certain limiting potential determined by the characteristic of the tube.

29 In the drawing, Fig. 1 is a schematic diagram illustrating a simple embodiment of the invention and Fig. 2 is a typical characteristic curve illustrating its mode of operation.

Referring to Fig. 1, T is an amplifier tube, preferably a thermionic tube of well known construction having an anode A, a control electrode or grid G and an electron emitting cathode or filament F. The input electromotive force is applied to the control electrode G by any suitable means such as the input transformer P_1S_1. B is a source of power whose output is controlled by means of the control electrode G. In the arrangement shown it is a source of electromotive force which produces the working thermionic current in the tube. The wave of variation of this current, or the electromotive force induced thereby, is taken off by suitable means such as the output transformer P_2S_2.

Instead of employing a metallic or conductive connection between the grid G and the cathode F, as is usual in the art, thus impressing a definite mean or base potential on the control electrode, I provide for an interruption of this connection, which may be either complete or partial, as by means of a flotation element C. This is preferably a capacity, suitably chosen with respect to the frequency of the currents to be amplified, so that it will constitute a path for the alternating currents between the cathode and the control electrode but will wholly or partially prevent the flow of a direct current. The control electrode or grid G is thus enabled to acquire a floating mean potential on which the input waves or potential variations are superimposed, the value of this floating potential being determined by the strength of the input impulses as will be explained in connection with Figure 2. The use of a capacity C as a separate element is not necessary. Any suitable means by which the grid is enabled to float at a suitable mean potential may be employed. When the system is suitably designed and proportioned the mere opening of the circuit at C will suffice.

Referring to Fig. 2, M N O P Q is a typical characteristic curve of an amplifier tube in which the ordinates represent the space current and the abscissas represent the potential of the control electrode G with respect to the cathode F. Initially, when no input electromotive force is applied to the amplifier, the control electrode G may be at or about zero potential and the condition of the apparatus will be represented by the point P on the characteristic curve. This condition is converted into the normal operating state as follows:

When an alternating electromotive force is applied to the control electrode G its potential will vary above and below that represented by the point P. A decreased potential will cause the control electrode to become negative with respect to the cathode, and a corresponding variation in the output current or electromotive force will occur, but no current will flow from control electrode to cathode. An increased potential of sufficient magnitude may cause the control electrode to become positive with respect to the cathode and a space current will then pass through the tube from control electrode to cathode. Each time that the control electrode becomes positive electrons are drawn to the control electrode, and thus a small fraction of the input wave is rectified and the control electrode acquires a negative charge which shifts its floating mean potential down on the curve. Each successive oscillation of the current will cause the negative charge on the control electrode to increase, until the resulting negative mean potential approaches a limiting point equal to the maximum positive value of the input potential. When this point is reached the maximum potential of the control electrode is zero,

rectification ceases, and no further current will flow from the control electrode to the cathode. The apparatus is now in normal operating condition, the floating mean
31 potential of the control electrode has been shifted to a point such as O, and the working potential variations occur above and below this point, for example, from *a* to *b*, the point *a* coinciding in this case with the point P. If the applied potential variations are reduced the working potential of the control electrode will vary over a narrower range, for example from *a′* to *b′*, the floating or mean potential remaining at O as before. Thus the control electrode, being free from any definite impressed electromotive force, floats or remains at a substantially steady but indefinite mean potential determined by the maximum signal strength, on which are superimposed the working waves of potential or electromotive force. If the characteristic curve is straight over the range *a, b* the resulting variations of output current or electromotive force will be directly proportional to the variations of input electromotive force, the amplification will be distortionless and the resulting output wave will be an amplified replica of the input wave. Such distortionless amplification is secured for any wave form or current strength within the limit of capacity of the tube, determined by the length of the straight portion of the characteristic.

The position of the floating point O on the curve is determined automatically by the strength of the impressed wave. If the applied electromotive force is small the floating point O will be only a small distance below the point P, this distance being sufficient to prevent rectification. If the applied electromotive force is larger the floating point O will be further down on the curve, and in each case the tube will operate with waves of working potential above and below this point. There is no material rectification in the tube and no resulting distortion after the lapse of the very brief interval of time required to establish the floating potential O. This starting interval is so small as to be imperceptible in practice. If the insulation of the
32 apparatus including the flotation element or condenser C is high this working point will remain constant. In practice however, there will be a slight leakage of the charge from the grid, causing a tendency of the floating point O to move upward, which tendency is counter-

acted by a very slight rectifying action whenever the variations of potential become great enough to make the control electrode momentarily positive. The floating point is thus maintained substantially constant and this is accomplished by the rectification of a very small fraction of the input wave.

A small amount of leakage is sometimes desirable in case the apparatus is subjected to an abnormal electromotive force which would cause the floating point O to move too far down on the curve. A slight leakage will then bring the floating point back to the normal working value. The imperfect insulation of the apparatus is usually sufficient for this purpose. In any case the leakage should not be so great as to produce rapid fluctuations of the floating potential, which would cause distortion of the output wave.

The capacity of the condenser C, when it is employed, is preferably so chosen that its reactance is low with relation to the impedance of the tube and transformer secondary S_1, so that it does not unduly absorb the working electromotive force. A relatively large capacity also prevents fluctuation of the floating point. On the other hand its capacity preferably should not be much larger than is necessary for these purposes, in order that the control electrode G may acquire the requisite floating charge with a very small rectification and that the time of recovery from an overcharge be not unduly prolonged.

33 It will be noted from the above that the floating grid or control electrode causes the amplifier to function automatically without distortion. When the input waves are weak the floating point O will be high on the curve, when they are strong it will be lower on the curve, but always the operating range is on the straight or distortionless portion of the curve provided the input waves do not exceed the normal operating strength for the particular tube employed and the floating point remains substantially constant, giving steady and uniform operation.

A clear distinction should be drawn between the operation hereinbefore described and the use of a grid condenser and grid leak in a detector of high frequency currents. In the latter case there is a continuous rectification of the high frequency current which produces audio frequency variations of grid potential, and these variations produce in turn variations of output current corresponding to the audio frequency variations in the strength of the high frequency signals. The continuously rectified current is carried off from the grid by the grid leak and this process of continuous rectification and continuous leaking causes rapid audio frequency variations in the grid potential which cause the device to act as a detector or integrating device, totally changing the character of the wave from a high frequency input to a low frequency output.

In operation in accordance with the present invention, on the other hand, there is no detecting or integrating function converting high frequency impulses into low frequency signals, but a simple amplification of the impressed impulses without change of wave form or frequency. There is no process of continuous and substantially complete rectification with a corresponding variation of the mean grid potential. The grid or control electrode is floating,
that is, it attains at once a mean or floating potential
34 at which it remains practically constant, with no
material variation under normal working conditions,
rectification occurs only for a very brief moment at starting or to replace the slow loss of charge due to imperfect insulation, and the apparatus operates about this substantially constant floating point to produce distortionless amplification without change of frequency or modification of
the impressed wave form.

35 I claim as my invention:

1. In an amplifier of electrical current waves, an input circuit, an output circuit and a floating control electrode, free from a definite impressed electromotive force, associated with the input circuit.

2. In an amplifier of electrical current waves, an anode, an electron emitting cathode, a control electrode, and a flotation element associated with the control electrode and maintaining it at a substantially constant but indefinite mean potential.

3. In an amplifier of electrical current waves, an anode, an electron emitting cathode, a control electrode, and a flotation element of low direct conductivity associated with the control electrode and maintaining it at a substantially constant but indefinite mean potential.

4. In an amplifier of electrical current waves, an anode, an electron emitting cathode, a control electrode, and a capacity associated with the control electrode in which a

substantially constant charge is established by rectification, and means whereby the input waves excite in the control electrode potential variations superimposed on the potential due to this charge.

5. The method of amplifying an electrical current wave which consists in exciting a substantially steady floating charge, superimposing potential variations produced by the wave on the floating charge, and controlling by these potential variations the output of a source of power in accordance with the wave form of the original wave.

6. The method of amplifying an electrical current wave
which consists in exciting a substantially steady floating
charge by rectification of the current wave, superimposing
potential variations produced by the wave on the
36 floating charge, and controlling by these potential
variations the output of a source of power in accordance with the wave form of the original wave.

7. The method of amplifying an electrical current wave which consists in exciting a floating charge by rectification of a small fraction of the current wave, superimposing potential variations produced by the wave on the floating charge, and controlling by these potential variations the output of a source of power in accordance with the wave form of the original wave.

8. The method of amplifying an electrical current wave which consists in exciting a floating charge, superimposing potential variations produced by the wave on the floating charge, and controlling by these potential variations the flow of a space current excited by a source of power in accordance with the wave form of the original wave.

9. The method of amplifying an electrical current wave which consists in exciting a floating charge, superimposing on the floating charge potential variations produced by the wave, and producing by these potential variations current variations directly proportional to the potential variations whereby an amplified replica of the original wave is produced.

10. In an amplifier of electrical current waves, a thermionic tube containing a cathode, an anode and a control electrode and having a current-electromotive force characteristic which has a rectilinear portion, means for main-

taining the potential of the control electrode within the rectilinear portion of the characteristic curve, comprising means for exciting on the control electrode a floating potential depending on the maximum amplitude of the input wave, means for superimposing on this floating potential variations of potential produced by the input wave, and a
source of power whose output is determined by these
37 variations of potential in accordance with the rectilinear characteristic.

38 This specification signed this 20th day of November, A. D. 1923.

FREDERICK K. VREELAND.

Oath.

STATE OF NEW YORK,
County of New York, ss:

Frederick K. Vreeland, the petitioner above named, being duly sworn, deposes and says, that he is a citizen of the United States, and a resident of 228 Orange Road, Montclair, Essex County, New Jersey; that he verily believes himself to be the original, first and sole inventor of the improvements in amplification of electric current waves described and claimed in the annexed specification; that he does not know and does not believe that the same were ever known or used before his invention or discovery thereof, or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United States for more than two years prior to this application; that said invention has not been patented in any country foreign to the United States on an application filed by him or his legal representatives or assigns more than twelve months prior to this application, and that no application for patent on said improvements has been filed by him or his representatives or assigns in any country foreign to the United States.

FREDERICK K. VREELAND.

Subscribed and sworn to before me this 20th day of November, A. D. 192-.

ELLA J. KINGER,
Notary Public.

[Seal.]

(Here follows drawing, side folio 39.)

Fig. 1.

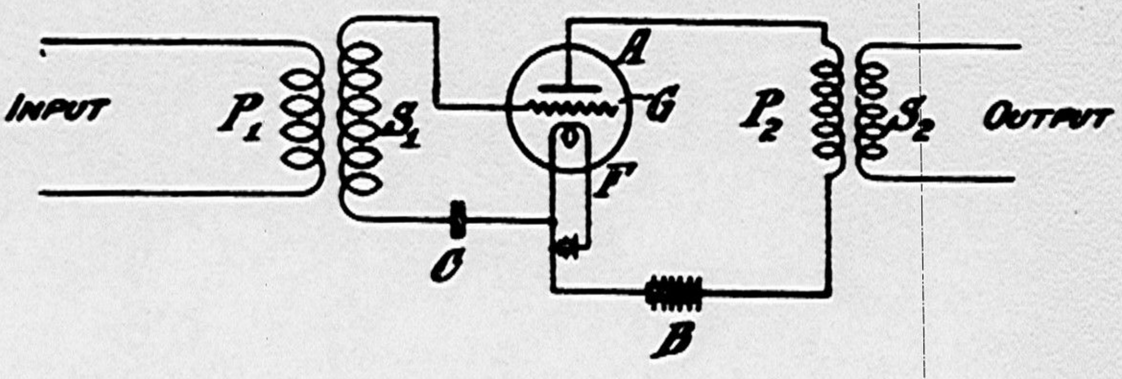
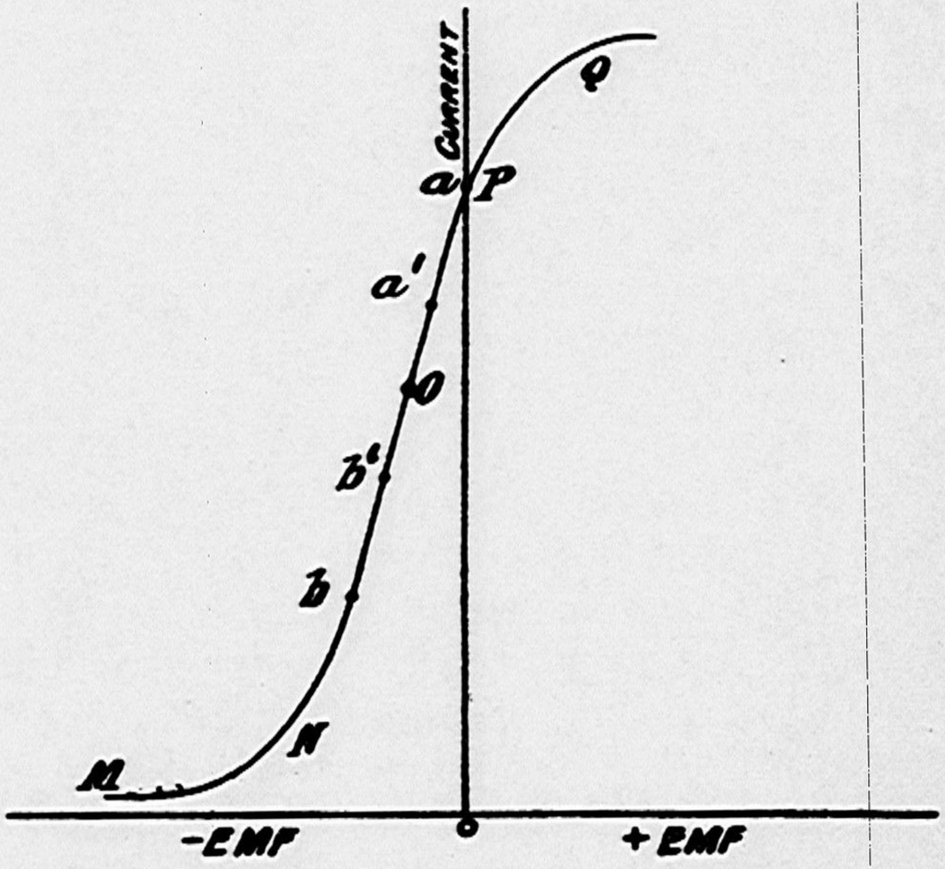


Fig. 2.



5839
Vreeland Corporation
vs.
Thomas E. Robertson, as
Commissioner &c.

INVENTOR
Frederick K Vreeland
BY
Redding Greeley, O'Shea & Campbell
ATTORNEY

40 [Stamp:] Patent Office, Div. 51, Filed Feb. 16, 1926.

[Stamp:] Mail Room, U. S. Patent Office, Feb. 15, 1926.

Paper No. 6.

Amendment A.

United States Patent Office.

Div. 51, Room 240, Annex.

Amendment.

In the Application of Frederick K. Vreeland. Serial No. 675,995. Filed November 21, 1923. Amplification of Electric Current Waves.

No. 38 Park Row,
New York City, February 13, 1926.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

In response to the official action of September 12, 1925, we beg to amend the above entitled case as follows:

Cancel claims 1, 2, 3 and 4 and substitute the following:

A′. 1. In an amplifier of electrical current waves, an amplifier tube including a control electrode, a flotation element associated therewith having such a
and resistance
Per B. capacity ∧ as to maintain the control electrode at a substantially constant but indefinite mean potential but not to modify the transmission of the working current waves, input means whereby working potential variations are superimposed on said mean potential, and output means responsive to amplified output variations corresponding to said working potential variations but not responsive to slow fluctuations of the substantially constant mean potential.

41 2. In an amplifier of electrical current waves, an amplifier tube including a control electrode,

a flotation element associated therewith and acquiring a negative charge by rectification, having such
and resistance
Per B. a capacity ^ as to maintain the control electrode at a substantially constant but indefinite mean potential, but not to modify the transmission of the working current waves, input means whereby working potential variations are superimposed on said mean potential, and output means responsive to amplified output variations corresponding to said working potential variations but not responsive to slow fluctuations of the substantially constant mean potential.

3. In an amplifier of electrical current waves, an anode, an electron emitting cathode and a control electrode, input
working
" B. means impressing ^ potential variations on the control electrode, a flotation con-
with associated overflow means
" B. denser ^ located between the control electrode and the cathode acquiring a negative charge by rectification and having
and resistance
" B. such capacity ^ as to maintain the control electrode at a substantially constant mean potential on which the input variations are superimposed, but not to modify the amplitude or wave form of such variations, output means associated with the anode and responsive to amplified
working
" B. output variations corresponding to the ^ input potential variations but not responsive to slow fluctuations of the substantially constant mean potential.

42 "With associated overflow means." What is that?

4. In an amplifier of electrical current waves, an anode, an electron emitting cathode and a control

working
Per B. electrode, input means impressing ∧ potential variations on the control elec-
with associated overflow means
Per B. trode, a flotation condenser ∧ located between the input means and the cathode acquiring a negative charge by rectifica-
and resistance
Per B. tion and having such capacity ∧ as to maintain the control electrode at a substantially constant mean potential on which the input variations are superimposed but not to modify the amplitude or wave form of such variations, output means associated with the anode and responsive to amplified output variations corresponding to the
working
Per B. ∧ input potential variations but not responsive to slow fluctuations of the substantially constant mean potential.

After "charge" in line 3 of claim 5 and line 2 of claim 8, and after "wave" in line 3 of each of claims 6 and 7, insert

Per B.

A². —which does not modify the working current wave, deriving from such charge a substantially steady mean control potential,—

[Matter enclosed between rules erased in copy.]

After "superimposing" in line 3 of each of claims 5 and 6, lines 3 and 4 of claim 7 and lines 2 and 3 of claim 8, insert —on said mean potential—

Erase "on the floating charge" in line 3 of claim 5, line 4 of claim 6, lines 4 and 5 of claim 7, and lines 3 and 4 of claim 8.

After "wave", the last word of line 6 of claim 5, line 7 of claim 6, line 7 of claim 7, and line 7 of claim 8, insert

Per B.

A³. —and independent of slow fluctuations of the floating charge.—

[Matter enclosed between rules erased in copy.]

43 After "proportional to" in line 5 of claim 9, insert —and having the same wave form as—

Remarks.

The applicant appreciates the intelligence of the consideration given to this case by the Examiner and the evident desire of the Examiner to accord to the applicant such protection as the invention is entitled to receive. In amending the claims the applicant has endeavored to conform to the suggestion made by the Examiner with respect to the placing of a relative value on the grid condenser, without attempting to place thereon a specific value of an absolute character which would be undesirable and impracticable.

Former claim 9, which has been amended but slightly, and former claim 10, both seem to the applicant to define the invention substantially in accordance with the suggestion of the Examiner without substantial change.

Attention is called to the fact that the purpose of applicant's device is to maintain the control electrode or grid at a substantially constant mean potential on which the input potential variations due to the signals are superimposed, and to translate these potential variations into amplified output variations of similar form, the output means being responsive to these output variations, and non-responsive to steady changes in anode current due to slow fluctuations of grid potential. To this end, applicant's flotation element is adapted to acquire and hold a charge which keeps the mean potential of the grid steady as the signal variations are superimposed on it, and the relation of the parts is the most favorable for this purpose, i. e., the input transformer is shown connected directly to the grid, so that the grid is subjected to the full signal potential variations of the transformer, and
44 the flotation element or condenser C, is preferably located between the input transformer and the filament, maintaining the filament terminal of the transformer at a substantially constant but indefinite floating potential. The result of this arrangement is that the flotation element, acting through the input means, maintains the control element at a relatively constant floating potential, whereas the input means operates with full effect to

superimpose potential variations on this floating potential.

The Langmuir device is not an amplifier but a detector. The well-known condenser and grid leak are used to absorb the rectified radio frequency input currents, which set up in the condenser a rapidly increasing charge whose resulting increasing potential controls the anode current or audio frequency output. When the signal ceases this charge is at once shunted away by the leak. The operation of Langmuir's device is thus essentially one in which the average potential of the grid is not substantially constant, as in applicant's device, but is rapidly changing, since it is this rapidly changing average potential that produces the useful audio frequency output. This useful output is not an amplified replica of the input variations, as in applicant's device, but is the integrated effect corresponding to the changes of the average potential of the grid. It is thus clearly distinguished from applicant's device, the essence of which is to set up a substantially constant mean potential on which the input variations are superimposed, these input variations being amplified in their original form and not transformed into currents of lower frequency, and the output means being non-responsive to slow fluctuations of the substantially constant mean potential.

Applicant's device is further distinguished from Langmuir's by the physical location of applicant's flotation element between the input means and the cathode, as stated in certain of the amended claims.

45 The DeForest reference is a selective audio amplifier whose object is to amplify currents of high frequency to a greater degree than currents of a lower frequency. This purpose is diametrically opposite to applicant's purpose of distortionless amplification of currents of all frequency.

To accomplish his purpose, DeForest employs damped tuned circuits between the grid and the filament which are intended, in cooperation with the other elements of the system, to strengthen selectively currents of higher frequencies. Together with these shunted selective circuits, DeForest employs a capacity in the input circuit of the amplifier, which is shown alternatively as a break in the transformer winding or as a series condenser, or both. The function of this series capacity is not explained, but it may be reasonably presumed that it is intended to augment the frequency selective action of the amplifier. It is well known that a capacity offers a lower impedance to currents of high frequency than to currents of lower frequency, and presumably this property of series capacity is utilized in conjunction with the shunted selective circuits to augment the frequency selective action of the amplifier.

It is certain that DeForest's purpose is diametrically opposite to that of applicant's, which is to produce an amplifier that will reproduce, without distortion or selective action, all frequencies impressed upon it. Applicant's flotation element or condenser is so proportioned with respect to the other elements that it has no effect on current waves of the working frequencies, but acts merely as a reservoir to maintain the potential level of the control electrode or grid at a substantially constant value while permitting the ripples of potential variations to vibrate unimpeded above and below this level.

46 Since DeForest gives no explanation of the function of his condenser, and since this condenser is used in an apparatus whose purpose is inconsistent with that of applicant's, it does not appear reasonable to regard this as an anticipation. It is well known in this art that condensers perform many different functions, such as stopping, by-passing, tuning, etc. and the mere showing of a condenser on a diagram, without explanation, does not disclose its function.

In a highly specialized case like this, DeForest's vague showing of a condenser in a location unfavorable to applicant's purpose, and in connection with an apparatus designed for a contrary purpose, should not constitute an anticipation.

It is hoped that the application as now presented will be found to be in allowable condition.

Respectfully submitted,
REDDING, GREELEY, O'SHEA &
CAMPBELL,
Attorneys for Applicant.

[Endorsed:] Assembled by P. B. Revised by P. B. Letter No. 545,972. Date: 7/20/32.

47 [Stamp:] Mail Room, U. S. Patent Office, Jul. 6, 1927.

[Stamp:] Patent Office, Div. 51, Filed Jul. 7, 1927.

Paper No. 8.

Amendment B.

United States Patent Office.

Div. 51, Room 240, Annex.

Amendment.

B.

In the Application of F. K. Vreeland. Serial No. 675,995. Filed November 21, 1923. Amplification of Electric Current Waves.

No. 38 Park Row,
New York City, July 5, 1927.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

In response to the official letter of July 10, 1926, we beg to amend the above entitled case as follows:

Page 2, line 15, change "conductive" to —direct—; line 18, before "interruption", change "an" to —a partial—; line 19, erase "which may be either complete or partial"; line 23, erase "wholly or"; lines 31, 32 and 33, erase the sentence beginning "When the system".

Page 5, line 2, before "high" change "is" to —were— and after "point" change "will" to —would—; line 3, after "there" change "will" to —should—; line 4, after "grid" insert —and flotation element—; line 11, erase "sometimes"; line 13, before "cause" insert —produce an excessive potential and—; line 14, after "leakage" insert —or shunting of the floating charge—; Lines 15, 16 and 17, erase the sentence beginning "The imperfect" and substitute

B^1. —The floating charge is automatically replenished and maintained at its normal value by partial rectification of the current wave as above explained.—;

48 line 19, after "wave" change the period to a comma and insert:

B^2. —or to require rectification of more than a small fraction of the input current wave.—;

line 20, erase "when it is employed".

Page 6, line 10, after "operation." insert:

B^3. —When an input wave of excessive strength is applied the floating point falls to such an extent as to block temporarily the supply of power from the source B, and the flotation element thus acts as a safety value to limit the output of the amplifier to a normal value. This limitation is automatically removed as soon as the input wave returns to normal strength.—

Page 7, lines 4 and 5, erase "imperfect insulation" and substitute —leakage in the flotation element—.

After "capacity" in line 4 of claim 1; line 5 of claim 2; line 7 of claim 3 and line 7 of claim 4, insert —and resistance—.

Insert —working— before 'potential" in line 3 of claim 3 and before "input" in line 12 of claim 3.

After "condenser" in line 4 of claim 3 and in line 4 of claim 4, insert —with associated overflow means—.

Insert —working— before "potential" in line 3 of claim 4 and before "input" in line 13 of claim 4.

Cancel claims 5, 6, 7 and 8 (original).

In claim 10 (original), line 8, after "wave" insert —and means for reducing excessive values of the floating potential—; line 9, before "variations" insert —working—.

Add the following claims:

B^4. 49 11. The method of amplifying an electrical current wave which consists in exciting a floating charge by rectification of a small fraction of the current wave which does not modify the working current wave, deriving from such charge a substantially steady mean control potential, superimposing on said mean potential, working potential variations produced by the wave, controlling by the working potential variations the effective output of a source of power in accordance with the wave form of the original wave and independent of slow fluctuations of the floating charge, reducing excessive potentials by shunting the floating charge at a rate that is slow compared to the rate of the working potential variations, and automatically replenishing the charge by partial rectification of the current wave.

12. The method of amplifying an electrical current wave which consists in exciting a floating charge by rectification of a small fraction of the current wave which does not modify the working current wave, deriving from such charge a substantially steady mean control potential, superimposing on said mean potential, working potential variations produced by the wave, controlling by the working potential variations the flow of a space current excited by a source of power in accordance with the wave form of the original wave and independent of slow fluctuations of the floating charge, reducing excessive potentials by shunting the floating charge at a rate that is slow compared to the rate of the working potential variations, and automatically replenishing the charge by partial rectification of the current wave.

50 Remarks.

The specification and claims have been properly amended to bring out clearly the features of method and apparatus which distinguish applicant's invention from what is shown in the references of record. Original claims 5, 6, 7 and 8 have been cancelled and two new claims, numbered 11 and 12, have been added in substitution for former claims 7 and 8 in order to avoid the confusion which might have resulted from successive amendments.

The new references cited in the official letter of July 10, 1926, appear to have the effect of limiting the scope of applicant's claims, but they do not disclose the features that particularly characterize applicant's invention.

The Lowell patent relates to a device for operating a receiving set, including a radio frequency amplifier and an audio frequency amplifier, from an alternating current supply. There is no suggestion of a flotation element in the audio frequency amplifier, and thus no anticipation of the particular feature of applicant's invention, which is distortionless amplification of an *audio* frequency current wave. As is well known, modification of the wave form of a modulated radio frequency wave does not produce distortion of the audio frequency output, since this is determined by the variations of amplitude of the radio frequency wave due to modulation and not to variations in the wave form.

The element 29 referred to by the Examiner is applied to the *radio* frequency amplifier only, where applicant's feature of distortionless reproduction of the wave form does
not apply. Furthermore, the character of the ele-
51 ment 29, as explained in the specification, is not such
as to produce a result even analogous to that of applicant, if such analogy may be assumed to exist in a radio frequency amplifier. The specification states that the capacity of the element 29 is 1 microfarad and the resistance 1 megohm. This is in marked contrast with applicant's apparatus, in which the capacity of the floating element may be of the order of .01 microfarad and the resistance from 10-20 megohms. The contrast is the more striking when account is taken of the frequency difference. Thus Lowell not only employs a capacity which is of the order of one hundred times that of applicant, but in addition, the use of this capacity in radio frequency makes its reactance of the order of one-thousandth of one-hundredth, that is of the order of one-thousandth of the reactance of applicant's flotation element. This enormous difference in capacity reactance cannot be regarded as a difference in degree, but indicates a real difference in function.

Lowell does not state clearly what the function of his element 29 is , except in a general way "the latter serving to keep the grids of the tubes 3 and 4 at the proper operating voltage, making the tubes more suitable for amplifying." Presumably this condenser was employed as a stabilizing condenser to absorb alternative current fluctuations which are not completely eliminated by the balancing resistance 17, and the grid lead 29 was shunted across the condenser to maintain the grid at the steady potential determined by the tap at the neutral point of this resistance 17.

The values given by Lowell, compared with applicant's values, show that Lowell's element 29 could not operate as a flotation element, like that of applicant, for the reason that the radio frequency tube 3 would be required to rectify
sufficient energy to supply the large loss through
52 the relatively low resistance of 1 megohm, and have
enough left over to charge the relatively enormous
condenser to a sufficiently high floating potential. It is clear that the tube 3 could not be expected to supply this requisite amount of energy, when it is considered that the available energy applied to the rectifier tube 3 is perhaps of the order of one-millionth of the energy supply to a power tube as employed by applicant, the values above stated as illustrating applicant's invention being values suitable for use with a power tube.

It seems clear, furthermore, that Lowell had no conception of applicant's invention, for the reason that he did not use it in the location where it would carry out applicant's process, namely, in floating the grid of the power tube 37. There is nothing resembling a flotation element in the audio frequency amplifier, which requires the usual bias or C battery 35. If Lowell had any conception of applicant's invention, he would certainly have applied it at this point.

All these considerations make it clear that Lowell's element 29 is not a flotation element responding to applicant's claim.

The new DeForest reference is more definite than the DeForest reference formerly cited, but even this is very vague as to the purpose of the open circuit points 37, 30 and 53, which vary so widely among themselves that they mean almost anything, except the particular and very specific features of applicant's invention. The only definite thing about these features as disclosed by DeForest's specification is that the side of the secondary of the transformer opposite to the grid "is open circuited". In all DeForest's showing this open circuit is complete. There is no suggestion of ap-
plicant's feature of a shunted resistance in his flota-
53 tion element, which serves to stabilize the apparatus,
absorbing excessive potentials and maintaining the
grid automatically at a normal floating value. All of applicant's claims as now amended contain this feature, the broader claims which might be considered readable on DeForest having been cancelled.

In addition to the lack of this feature, DeForest also fails to disclose the particular relations of parts required to produce distortionless amplification in applicant's invention, which relations are set forth in the several claims.

These remarks as to the distinction between the applicant's invention and the Lowell and the new DeForest references are applicable in greater degree to the references formerly cited, which do not approach applicant's invention as closely as the later ones.

It is believed that the claims as now amended clearly distinguish over Butcher as well as the patent to DeForest. The claims now specify particular relations of the capacity and resistance, which are necessary to accomplish applicant's results. These relations could not be accomplished by the mere use of capacity between filament and ground, in the case of Butcher or the mere opening of the circuit as in the case of DeForest. Certainly these references do not disclose any resistance in the floating element, as required by claims 1, 2, 3 and 4, or any overflow means, as required by claim 4, or any means for reducing excessive potentials by shunting the floating charge, as required by claims 7, 8 and 10, as amended.

It is believed that the claims as now amended will be found to clearly distinguish from the references.

Respectfully submitted,

REDDING, GREELEY, O'SHEA & CAMPBELL,
Attorneys for Applicant.

54 [Endorsed:] Assembled by P. B. Revised by P. B. Letter No. 545,972. Date: 7/20/32.

Endorsed on cover: District of Columbia Supreme Court. No. 5839. Vreeland Corporation, appellant, vs. Thomas E. Robertson, as Commissioner, &c. Court of Appeals, District of Columbia. Filed Nov. 2, 1932. Henry W. Hodges, Clerk.

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L. DE FOREST.

METHOD OF AND MEANS FOR REPRODUCING AND AMPLIFYING WEAK PULSATING CURRENTS.

APPLICATION FILED SEPT. 8, 1914.

1,314,250. Patented Aug. 26, 1919.

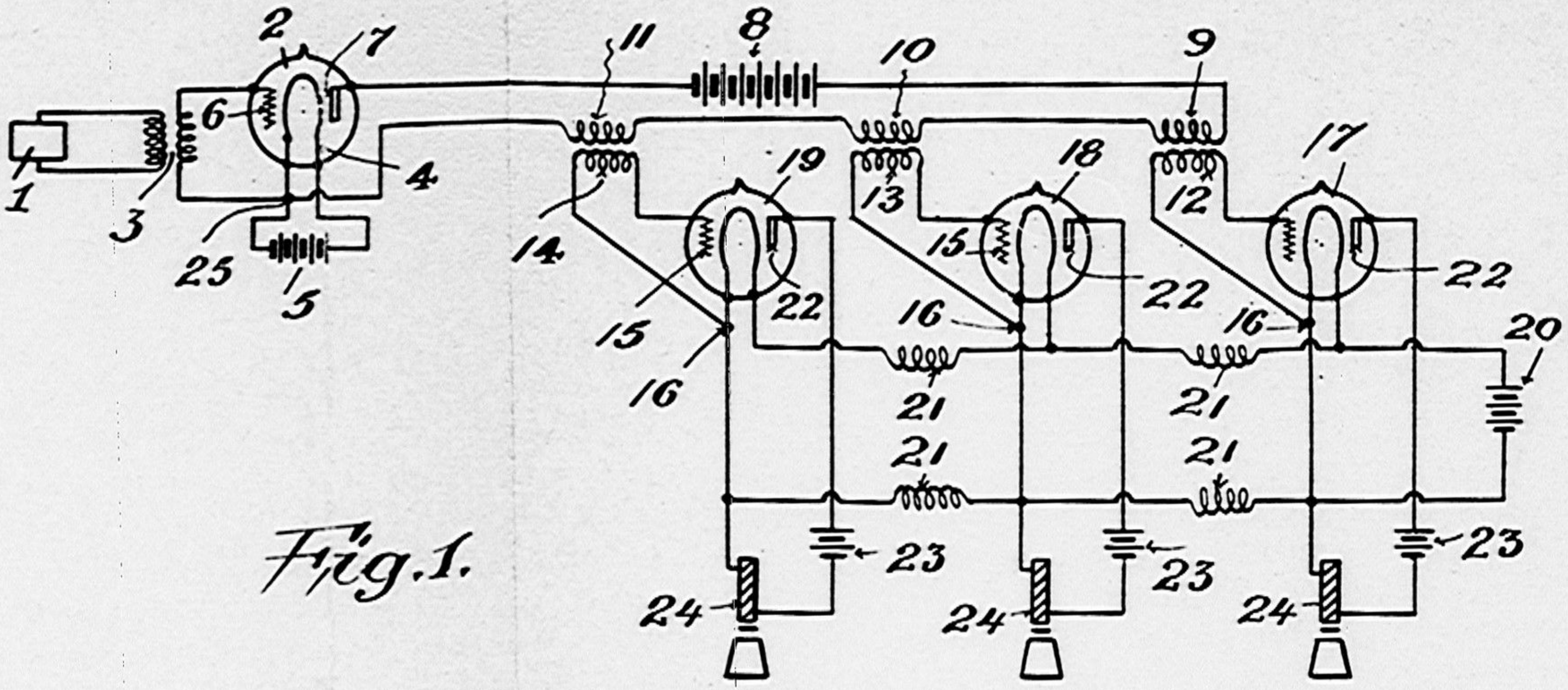
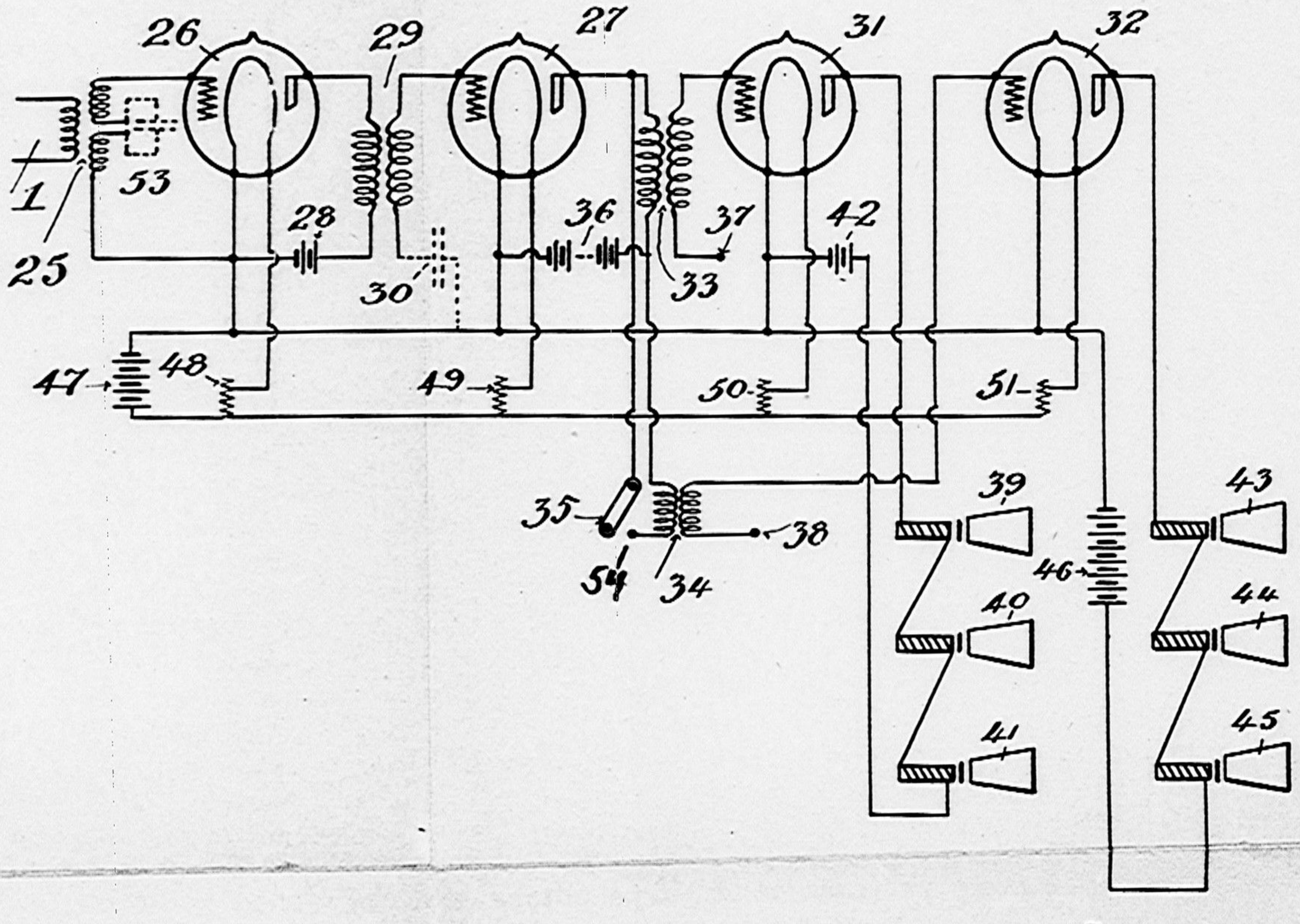


Fig. 1.

Fig. 2.



Witnesses:
C. W. Benjamin
S. E. Darby, Jr.

Inventor
Lee de Forest

By his Attorney Samuel E. Darby

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO DE FOREST RADIO TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF DELAWARE.

METHOD OF AND MEANS FOR REPRODUCING AND AMPLIFYING WEAK PULSATING CURRENTS.

1,314,250. Specification of Letters Patent. **Patented Aug. 26, 1919.**

Original application filed June 24, 1913, Serial No. 775,529. Divided and this application filed September 8, 1914. Serial No. 860,713.

To all whom it may concern:

Be it known that I, Lee de Forest, a citizen of the United States, residing at New York, in the county and State of New York, have made a certain new and useful Invention in Methods and Means for Reproducing and Amplifying Weak Pulsating Currents, of which the following is a specification.

This invention relates to methods of and means for reproducing and amplifying weak pulsating currents, and embodies subject matter divided from my prior application Serial No. 775,529, filed June 24, 1913.

The object of the invention is to provide means which are simple and efficient for reproducing and amplifying weak pulsating currents for use in connection with electroresponsive devices, such as sound emitting means, etc.

A further object of the invention is to provide a method and means of the character referred to whereby weak pulsating currents are reproduced and amplified at a plurality of points or stations.

A further object of the invention is to provide means whereby any desired degree of amplification is secured by means of a plurality of amplifiers wherein a common circuit is employed to supply current to the plurality of amplifiers.

Other objects of the invention will appear more fully hereinafter.

My invention consists substantially in the construction, location, relative arrangement of parts, and method of operation, all as will be more fully hereinafter set forth, as shown in the accompanying drawing, and finally pointed out in the appended claims.

Referring to the drawing:

Figure 1 shows means for reproducing and amplifying weak pulsating currents at a plurality of locations from a single source.

Fig. 2 shows another arrangement for accomplishing the objects and purposes of my invention.

In accordance with the principles of my invention I propose to employ weak pulsating currents from any suitable source and to amplify the same and utilize the amplified current for any desired purpose such as for the production of sound waves or for other purposes, and, in a somewhat more limited statement, to utilize the weak pulsating currents, in the manner and for the purposes stated, from a single source at a plurality of different points or locations, after amplifying the same.

My invention may be carried out in many different ways, and in the accompanying drawings I have shown two arrangements of operation and practical apparatus for the purpose.

Generally speaking, I employ one or more master amplifiers in the form of an audion, or audions, which initially receive the weak pulsating currents and amplifies them, and one or more auxiliary or secondary amplifiers in the form of audions which serve to increase the amplification of the currents and deliver the same to one or more different locations or points and to electro-responsive devices for practical utilization.

The amplifiers, master and auxiliary, are arranged in suitable circuit arrangement with respect to each other to enable them to accomplish their respective functions.

Referring to Fig. 1, reference numeral 1 designates schematically a source of weak pulsating current which is electrically connected to a master audion 2, by means of the transformer 3. The filament 4, of the master audion, is supplied with current from a suitable source, such as a battery shown at 5. The grid 6 of the same audion is connected to one terminal of the transformer 3, and the plate or wing 7 of the same audion is connected in circuit with a suitable source of current shown at 8, and in series with the primaries 9, 10, 11, etc., of the various transformers included in the separate circuits of the auxiliary or secondary audions, and the circuit continues to a terminal of the filament 4 of the master audion, which terminal is also connected to the other terminal of the secondary of transformer 3. The secondaries 12, 13, 14, etc., of the series of transformers are shown respectively connected to the grids 15, and one terminal of the respective filaments 16, of the auxiliary or secondary audions 17, 18, 19, etc. The filaments are supplied with current from a source shown at 20, such as a battery. I prefer to interpose reactance or choke coils 21 between the respective terminals of the filaments of the respective auxiliary audions to thereby prevent interaction between the said auxiliary audions. The plates or wings 22 of the secondary audions are connected in respective separate circuits comprising a source 23, electro-responsive device 24, to one side of the filament which is also connected to the secondary of its associated transformer. I prefer to use transformer 3 as a step-up transformer to raise the voltage of the weak pulsating current derived at 1. The transformers 9—12, 10—13, 11—14, etc., may be of any suitable type, but I prefer to use one-to-one two coil transformers. The reactances or choke coils 21 may be either of the adjustable type or of the fixed type, having a predetermined reactance. The electro-responsive devices indicated at 24 may be of any desired construction or character, and it is evident that they may be placed at points remote from one another as may be desired.

The operation of the arrangement described is apparently simple. The weak pulsating currents derived at source 1 are transmitted through the transformer 3 to the master audion 2 which amplifies the current and transmits the same by means of transformers 9—12, 10—13, 11—14, etc., to the auxiliary or secondary audions. Each of the auxiliary audions amplifies the current received thereby, and transmits the same to the electro-responsive devices 24 to be utilized as may be desired as hereinbefore described.

In Fig. 2 I have shown an arrangement wherein an audion is employed to act in the capacity of a step-up transformer between the source of weak pulsating currents and the master audion, and a plurality of auxiliary audions are employed associated with the master audion, and in parallel relation to each other, so that each auxiliary audion may control the action of a plurality of electro-responsive devices. In this arrangement the filaments of all of the audions employed are supplied with current from a common source. The weak pulsating currents are derived from any suitable source schematically shown at 1, which is electrically connected to audion 26 by means of the transformer 25. This transformer may be of any desired type, but I find it preferable to use a one-to-two step-up transformer, one end of the secondary of which is connected to the grid of audion 26, and the other end is connected to a terminal of the filament of said audion, which terminal is also connected to common source 47 and to the source 28. The other terminal of said filament is connected to the variable resistance 48 which completes the circuit of the filament to the source 47. The plate or wing of the audion 26 is connected to one side of the primary of transformer 29, the other side of which is connected to the remaining terminal of the source 28. The audion 26 is electrically connected to the master audion 27 by means of the transformer 29, one side of the secondary of which is connected to the grid element of said master audion and the other side of which is open circuited. One terminal of the filament of the master audion is connected to a current source 36, and also to the common source 47, and the other terminal is connected to the variable resistance 49, which completes the circuit of the filament to the common source 47. The plate or wing element of the master audion is connected to the primary of the transformer 33. This transformer may be of any suitable type, but I find it preferable to use a one-to-one two coil transformer. The wing of the master audion 27 is also connected to an open circuited gap indicated at 35. One side of the secondary of transformer 33 is open-circuited at 37, and the other side is connected to the grid of auxiliary audion 31. When more than one auxiliary audion is employed, the plate element of master audion 27 is connected to one side of a circuit including the primaries of as many transformers as there are auxiliary audions, said primaries being connected in series, and the other side of the circuit being open-circuited. I have shown, for illustrative purposes, two auxiliary audions 31, 32, said auxiliary audions being in parallel relation to each other and electrically connected to the master audion 27 by means of the transformers 33, and 34. The grids of the auxiliary audions are connected to one side of the secondaries of the respective transformers associated therewith, the other side being open-circuited. The filaments of the auxiliary audions are connected similarly to the filaments of audion 26, and master audion 27, to the common source 47, auxiliary source 42, and 46, respectively, and resistance 50 and 51 respectively. The plates of the auxiliary audions, however, are each connected to one or more electro-responsive devices in series, instead of the transformer as in the case of audion 26, or of the plurality of transformers, as in the case of master audion 27.

The current sources 28, 36, 42, 46, 47, etc., may be of any suitable type, but for illustrative purpose I have shown them as batteries. The resistances 48, 49, 50, 51, etc., may be of any variable resistance type well known to the art.

The operation of arrangements described is as follows:

The weak pulsating current derived at 1 is transmitted to the audion 26 through the step-up transformer 25. This audion serves to amplify the current received and transmits the same by means of transformer 29 to the master audion 27. The master audion in turn amplifies the received current, and by means of the transformers 33, 34, etc., transmits the same to the auxiliary audions 31, 32, etc., each of which amplifies the received current so that it may be utilized by their associated electro-responsive devices.

It is essential that the grids of the various audions should not be connected directly to any source of electro-motive force, while at the same time it is desirable to supply the filaments of all of the audions with current from the same source. I accomplish this by open circuiting one side of the secondaries of each of the transformers employed, as hereinbefore described. A condenser may be employed instead of the open-circuited gap as shown by dotted lines at 30 and 53, but I find that in practice I secure better results and more efficient reproducing and amplifying action by the respective audions, with one side of the secondaries of the transformers open-circuited.

It is clear from the foregoing description that a single auxiliary audion may be employed in connection with a single or plurality of electro-responsive devices in the arrangement described. It is also obvious that a plurality of auxiliary audions may be employed, each auxiliary audion having a single or plurality of electro-responsive devices, associated therewith.

Whereas I have illustrated particular forms and arrangements for reproducing and amplifying weak pulsating currents employing a master audion and auxiliary audions, it will be understood that other arrangements may be used without departing from the scope of my invention, and consequently I am not to be limited to the arrangements shown herein.

Having now set forth the object and nature of my invention, and construction embodying the principles thereof, what I claim as new and useful and of my own invention, and desire to secure by Letters Patent is,—

1. In an amplifying device for electric currents, a source of weak pulsating currents, an amplifying device associated therewith, a plurality of amplifying devices associated with said first named amplifying device, and means to prevent interaction between said plurality of amplifying devices.

2. In an amplifying device for electric currents, a source of weak pulsating currents, a master audion associated therewith, a plurality of auxiliary audions associated with said master audion, electro-responsive devices controlled by said auxiliary audions, and means to prevent interaction between said auxiliary audions.

3. The combination with a source of pulsating current, an amplifying device, an electro-responsive device controlled by said amplifying device, and an open circuited transformer intermediate said source and amplifying device.

4. The combination with a source of pulsating current, of an audion, an electro-responsive device controlled thereby, and a transformer to associate said audion with said source, said transformer having its secondary open-circuited.

5. The combination with a source of pulsating current, of an audion, an electro-responsive device controlled by said audion, and a transformer for associating said source and audion, the grid and filament elements of the audion, being connected to the secondary of the transformer, said secondary being open circuited.

6. The combination with a source of pulsating current, of an audion, a transformer having its secondary connected to the grid and filament elements of the audion, said secondary being open-circuited, and an electro-responsive device controlled by the wing element of the audion.

7. The combination with a source of pulsating current, of a master audion, a step-up transformer connecting said master audion and current source, a second master audion having its grid element associated with the plate element of said first mentioned audion, an auxiliary audion having its grid element associated with the second master audion, and an electro-responsive device controlled by said auxiliary audion.

8. The combination with a source of pulsating current, of a master audion, a second master audion associated therewith through a transformer, an auxiliary audion, a transformer associating said second master and auxiliary audions, the secondary of said last mentioned transformer being open-circuited, and an electro-responsive device controlled by said auxiliary audion.

9. The combination with audions operating as current amplifying devices and arranged in successive relation, of auxiliary audion amplifying devices arranged in parallel and associated with said first named audion amplifying devices, and electro-responsive devices controlled by said auxiliary audion amplifying devices.

10. The combination with a source of pulsating current, of an audion having its grid and filament elements in electrical connection therewith, a transformer having its primary connected to the wing element of said audion, a second audion having its grid and filament elements connected to one terminal of the secondary of said transformer, the other terminal of said secondary being open-circuited, and an electro-responsive device controlled by said second audion.

11. The combination with a source of pulsating current, of an audion having its grid element associated with said source, a plu-

rality of independent auxiliary audions having their grid elements associated with the wing element of the first named audion, and electro-responsive devices respectively controlled by the wing elements of said auxiliary audions.

12. The combination with a source of pulsating current, of an audion having its grid element associated with said source, a plurality of independent auxiliary audions, transformers associated with the wing element of said first named audion, the grid elements of the auxiliary audions being respectively associated with said transformers, and electro-responsive devices respectively controlled by the wing elements of said auxiliary audions.

In testimony whereof I have hereunto set my hand in the presence of the subscribing witnesses, on this 18th day of August, A. D. 1914.

LEE DE FOREST.

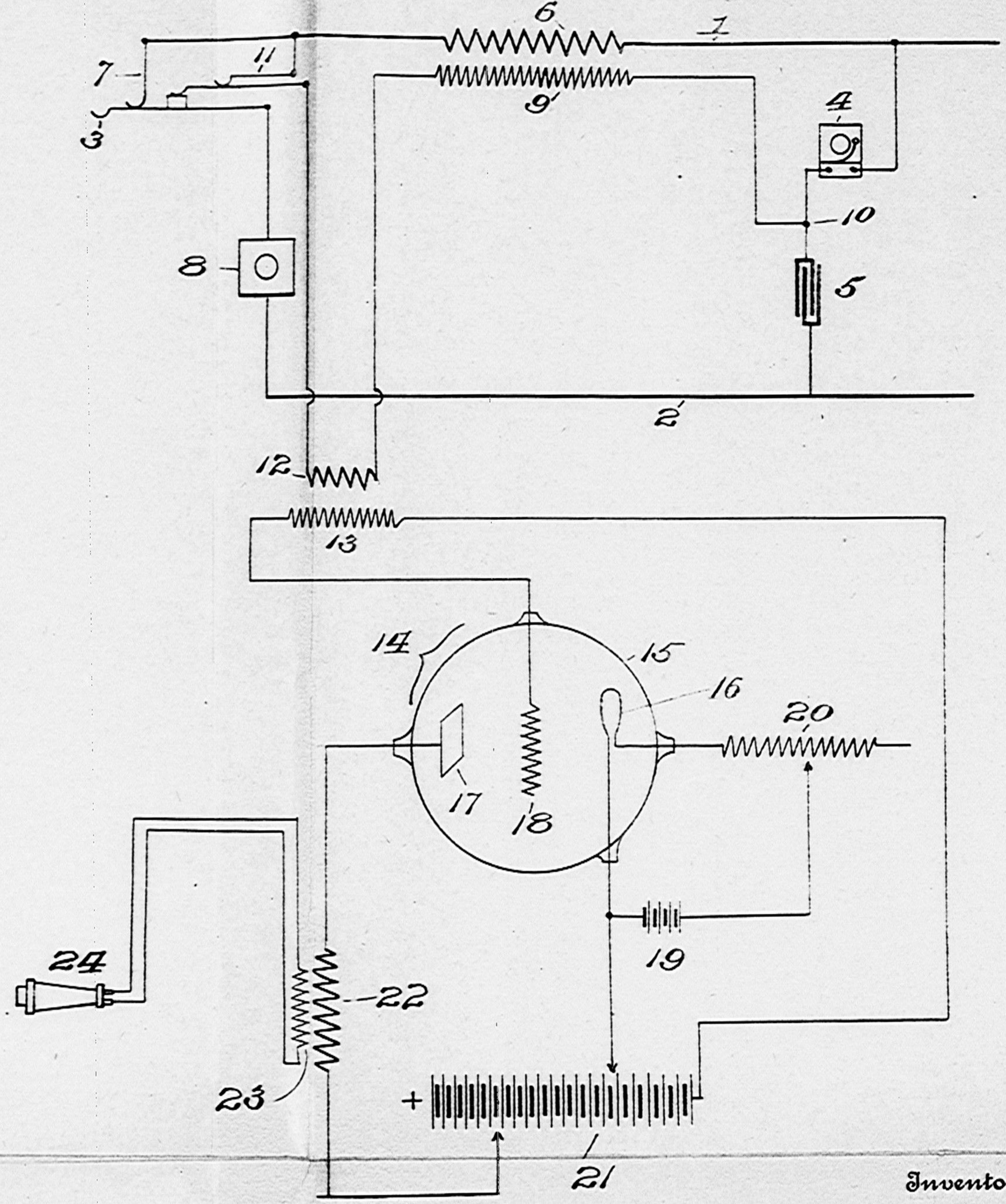
Witnesses:
SAMUEL E. DARBY, Jr.,
MARJORIE A. GRAEVE.

F. LOWENSTEIN.

TELEPHONE RELAY.

APPLICATION FILED APR. 24, 1912. RENEWED APR. 26, 1917.

1,231,764. Patented July 3, 1917.



Inventor

Witnesses

J. M. Fowler Jr.

Eugene C. Brown

Fritz Lowenstein

By M. C. Massie

his Attorney

UNITED STATES PATENT OFFICE.

FRITZ LOWENSTEIN, OF NEW YORK, N. Y.

TELEPHONE-RELAY.

1,231,764. Specification of Letters Patent. **Patented July 3, 1917.**

Application filed April 24, 1912, Serial No. 692,828. Renewed April 26, 1917. Serial No. 164,787.

To all whom it may concern:

Be it known that I, Fritz Lowenstein, a citizen of the United States, residing at New York city, in the county of New York and State of New York, have invented certain new and useful Improvements in Telephone-Relays, of which the following is a specification.

My invention relates to improvements in telephone relays.

The object of my invention is to provide a relay by means of which the relation of the potential differences of the complex incoming speech currents is well maintained in the telephone receiver so that the sound reproduced by the receiver diaphragm will be composed of waves of practically the same frequencies as impinge upon the transmitter diaphragm, and, what I consider most important, these various frequencies will have about the same relative amplitudes as in the original sound waves actuating the transmitter. As a result of this the reproduced sound is intelligible.

It is frequently the case with long distance telephoning that under certain conditions the sound of a speaker's voice may be heard very plainly in the receiver, while at the same time it is unintelligible. As a result of experiments I have ascertained that this lack of intelligibility is due principally to the fact that the speech currents of higher frequencies are attenuated to a greater relative extent than are the speech currents of low frequency due to electrical properties of a long line, so that the incoming speech current is distorted. Furthermore, this distortion is but little affected by terminal conditions, and hence relays or receiving apparatus functioning according to current values cannot remedy the distortion or compensate for the effects thereon.

On the other hand the terminal voltages are materially affected by terminal conditions, and hence it is possible to select such terminal conditions as will enable the relative amplitudes of the original voltages to be well maintained at the incoming end of the line. Therefore, a relay apparatus which functions according to terminal voltages is well adapted for the production of receiver operating currents of the desired absolute strengths and in the relative strengths necessary for the successful operation of the telephone receiver.

My invention will now be explained in connection with one embodiment thereof.

The drawing is a diagrammatic view of so much of one well known form of telephone system as is necessary to explain the construction and operation of my improved relay.

Referring first to the old elements of the system, it will be seen that two wires only, 1 and 2, are used for the three purposes of ringing, microphone operation and transmitting the talking current. When the station is not in use and the receiver is on hook 3 the line 1—2 is connected only through the bridge containing a bell 4 of high self-inductance and a condenser 5 proportioned so as to be in resonance with the self-inductance 4 on 16 cycles, which frequency is used for ringing current.

When the receiver is removed from the hook 3, the line 1—2 is closed also by way of primary 6 of the telephone induction coil, switch contact 7 and microphone 8. On the same core with primary 6 of the induction coil is secondary 9, one terminal of which is connected on the junction point 10 between the bell and condenser of the ringing circuit and the other terminal of which connects through the telephone receiver and contact switch 11 to one side of the primary 6 of the induction coil.

In applying my instrument I substitute for the usual telephone receiver the primary 12 of a step-up transformer which produces in its secondary 13 comparatively high potential. At 14 is an ion or an electron controller, or audion, consisting of a container 15 evacuated and provided with an incandescent filament 16, an anode 17 and a modulating or controlling member 18, which in the present example is a mere grid. Incandescent filament 16 is fed by battery 19 through an adjustable rheostat 20 which permits fine adjustments of the incandescence of the filament. A battery 21 is provided which furnishes current through the evacuated field, the positive pole of the battery being connected to anode 17, a negative point of the battery being connected to filament 16. The potentials created in secondary 13 are made to control the current flowing through the ionic field and originating in battery 21 by connecting the one terminal of coil 13 to the modulating member 18 and the other terminal of said coil to a point on the battery 21, which is located ultranegatively relative to the negative point of the battery connected to the filament. This ultranegative connection is especially desirable and constitutes an important feature of my invention in its preferred embodiment. The volume and clearness of speech as heard in the receiver in the arrangement shown is materially greater than where the grid 18 and coil 13 are connected, for example, to a point at the same potential as the filament 16. The theoretical considerations involved are somewhat abstruse and not fully understood; but the advantage of the ultranegative connection is fully established by repeated tests which I have carried out in actual practice. I therefore note the fact without attempting to explain it. Both the positive and the ultranegative points of connection to battery 21 are adjustable to enable variation of the driving potential of battery 21 for the ionic field and of the ultranegative potential. A telephone of many convolutions, may be inserted at 22, but to enable the use of the usual commercial telephone where desired, 22 should be a high winding of an induction coil transforming the energy from small current and high potential in coil 23 into a current of lower potential but higher amperage so as to make this energy more available for the commercial telephone receiver 24.

The operation of the ionic controller is as follows:

The incandescent filament 16 produces ionization of the gas contained in container 15 and thereby makes the gas a conductor. The potential between filament 16 and anode 17 derived from battery 21 creates a static field between such filament and anode which exerts a driving power on the ionized gas particles which come in contact with incandescent filament 16 and which are thereby electrically charged. A negative charge in an electric field is acted upon by a force in the direction of the field lines from negative to positive point of the field and the amount of negative current which is therefore conveyed through the field is dependent on the ionization power of the filament, the quantity of the individual charge and the strength of the electric field.

The ionization power of the filament is a function of its temperature and therefore of its incandescence. The individual charge is a function of the negative potential of the filament and also of the degree of evacuation. The intensity of the field is a function of the potential difference between filament and anode and of their distance, which two dependencies may therefore be expressed as the potential gradient of the field. Therefore the current in the ionic field circuit will increase with the incandescence of the filament, the potential difference of the battery and, up to a certain point, with the evacuation.

By providing a modifying or controlling device, such for example as the modulating means 18, which is subjected to an impressed potential more negative than that of the cathode and which is adapted and arranged to interpose between the anode and cathode a modifying or controlling field of the desired character, the potential gradient between the filament and the controlling device or modulating means may be changed and thereby the current which flows through the ionic circuit changed accordingly. By applying variable potentials to the modulating means 18 the currents in the ionic field circuit are varied accordingly and as the impressing of a potential on conductor 18 need not be accompanied by an appreciable expenditure of energy, whereas the energy of the ionic field circuit is varying considerably, I have a means to produce great changes of energy in that field circuit by variation of potentials which do not require appreciable energy.

Having thus fully described my invention, what I claim is:

1. Telephone apparatus comprising the combination, with a talking circuit, of a suitably energized relay circuit including an anode and a cathode separated by a conductive gap, a modulating device interposed in said gap and electrically connected with said talking circuit, means for impressing upon said modulating device a potential more negative than that of said cathode, and a translating device arranged to be energized from said relay circuit.

2. Telephone receiving apparatus, comprising the combination with a talking circuit, of an ion controller having an anode and a cathode connected in a second circuit electrically related to said talking circuit, a modulating device interposed between said anode and cathode, means for energizing said modulating device from said talking circuit and also from a source of potential which is negative with respect to said cathode, and a telephone receiver arranged to be energized from the controller circuit.

3. Telephone receiving apparatus comprising the combination, with a talking circuit, of an ionic controller having an anode and a cathode suitably spaced apart, a battery, connections from said anode and cathode to the battery, a grid electrically connected to said talking circuit and interposed between said anode and cathode, a connection from said grid to said battery, the battery connecton of the grid being negative with respect to the battery connection of the cathode, and a telephone receiver arranged to be energized from the controller circuit.

4. Telephone apparatus comprising the

combination, with a talking circuit, of a coöperating circuit suitably energized and including an anode and a cathode separated by a conductive gap, a modifying or controlling device interposed between said anode and cathode and subjected to an impressed potential more negative than that of said cathode, and a third circuit energized by said coöperating circuit.

5. The combination, with an exhausted container, and an anode and a cathode located therein and included in a suitably energized circuit, of a modifying or controlling device interposed between said anode and cathode and connected to a source of potential more negative than said cathode, and another circuit inductively related to the first mentioned circuit.

6. The combination, with an exhausted container, and an anode and a cathode located therein and included in a suitably energized circuit, of a modifying or controlling device connected to a source of potential more negative than said cathode and adapted and arranged to influence the character of the field between said anode and cathode, and another circuit inductively related to the first mentioned circuit.

7. The combination, with an audion having its anode and cathode included in a suitably energized circuit, of means for impressing upon the audion grid a potential more negative than that of the audion cathode.

In witness whereof I have hereunto affixed my hand this tenth day of January, 1912.

FRITZ LOWENSTEIN.

Witnesses:
O. F. ROTHEN,
L. BASCHANG.

May 15, 1923. 1,455,141

P. D. LOWELL ET AL

RADIO RECEIVING APPARATUS

Filed March 27, 1922 2 Sheets-Sheet 1

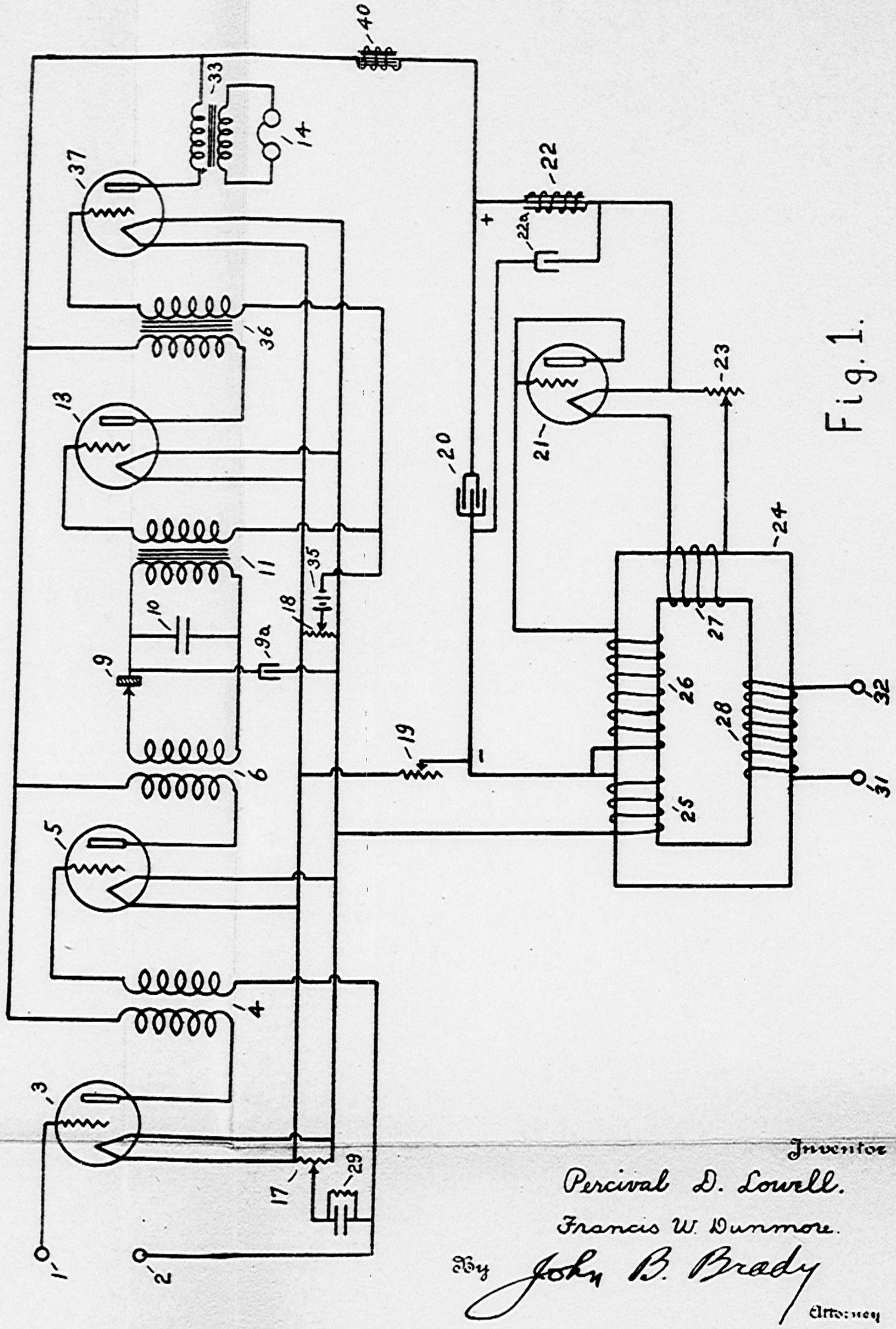


Fig. 1.

Inventor

Percival D. Lowell.

Francis W. Dunmore.

By John B. Brady

Attorney

49

May 15, 1923. **1,455,141**

P. D. LOWELL ET AL

RADIO RECEIVING APPARATUS

Filed March 27, 1922 2 Sheets-Sheet 2

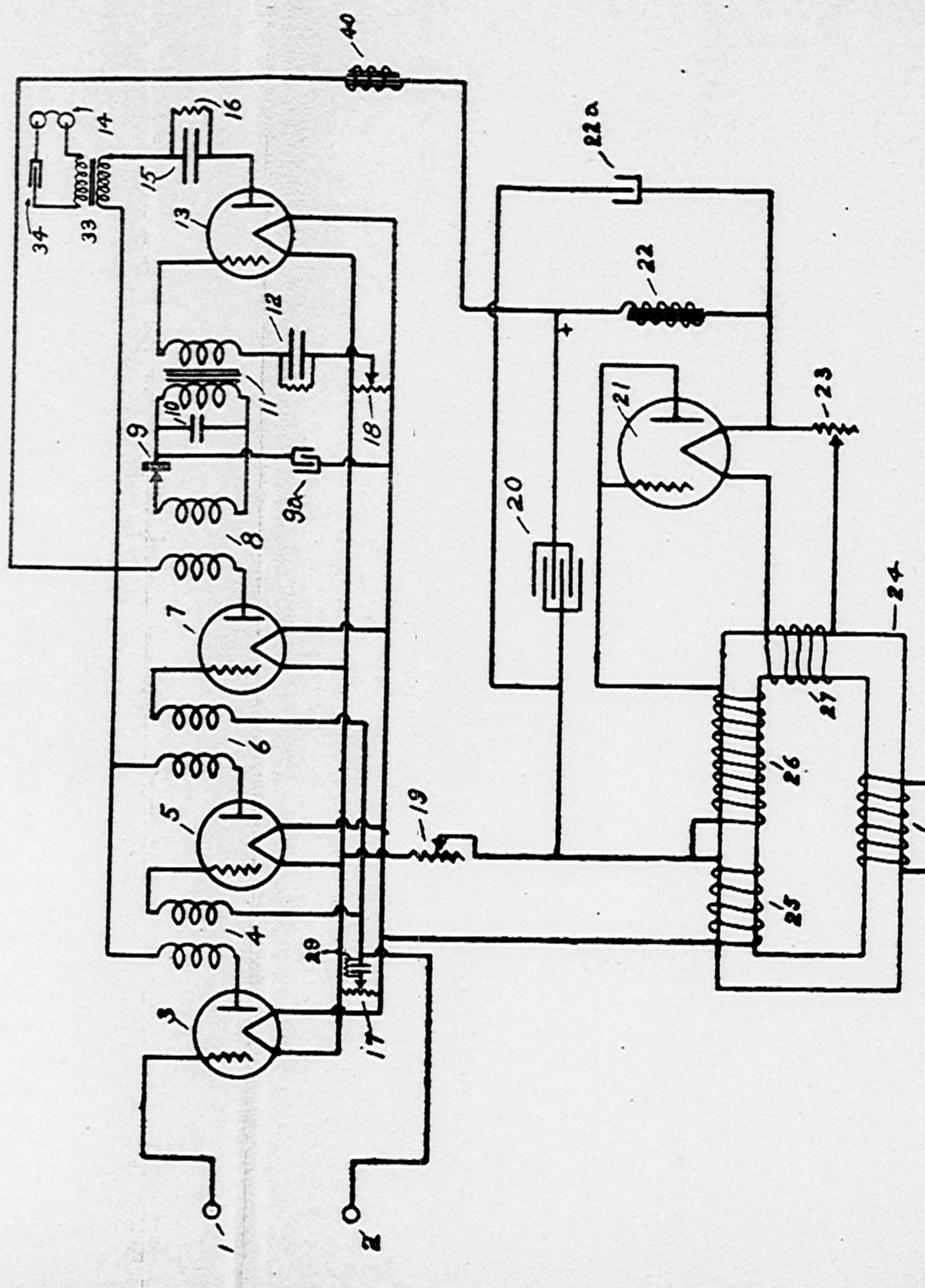


Fig. 2.

Inventor

Percival D. Lowell

Francis W. Dunmore

By John B. Brady

Attorney

Patented May 15. 1923. **1,455,141**

UNITED STATES PATENT OFFICE.

PERCIVAL D. LOWELL AND FRANCIS W. DUNMORE, OF WASHINGTON, DISTRICT OF COLUMBIA.

RADIO RECEIVING APPARATUS.

Application filed March 27, 1922. Serial No. 547,111.

To all whom it may concern:

Be it known that we, Percival D. Lowell and Francis W. Dunmore, citizens of the United States, residing at Washington, District of Columbia, have invented certain new and useful Improvements in Radio Receiving Apparatus, of which the following is a specification.

Our invention relates broadly to radio telegraph and telephone receiving apparatus and more particularly to a circuit arrangement for such receivers.

The object of the invention is to provide a receiver unit of maximum sensitivity employing thermionic vacuum tubes with their circuits supplied with energy from the standard alternating current residence lighting power.

Another object of the invention is to provide both radio and audio frequency amplification at the receiver and means for energizing the power circuits of the amplifier stages from the standard alternating current residence lighting power without interference in the reproducing receivers from the hum of the alternating current power supply.

A further object of the invention is to provide a circuit arrangement for a receiver wherein both the radio and audio frequency currents are amplified by means of electron tubes, a crystal detector used as a rectifier, the necessary filament and plate voltages being supplied by the standard alternating current residence lighting power, the residual hum in the telephone receivers being balanced out or neutralized by means of voltage dividers and other devices in the receiver circuits.

A still further object of the invention is to provide means in a radio receiver for transforming the alternating current power supply into currents suitable for the various circuits of the radio and audio frequency stages of the vacuum tube amplifiers and means for rectifying currents and obtaining a steady source of direct current potential for the plate circuits of the vacuum tubes.

Electron tube amplifiers form an important part of practically all radio receiving sets now, except the most simple types. Such amplifiers are in fact necessary to receive distant stations, or when using coil antennæ. For good operation, amplifier tubes require for the filament a source of voltage of very constant value (usually about 6 volts) and for the plate a source of voltage of from 40 to perhaps 300 volts. The filament voltage is usually supplied by storage cells, and the plate voltage by dry cells. The maintenance of these cells in operating condition, especially the storage cells, is often a source of much difficulty and annoyance. The storage cells are necessarily bulky and heavy, require constant attention to maintain proper charge and density of electrolyte, give off injurious acid or other fumes, and are subject to considerable variations of voltage during the period of discharge. The development of a receiver employing an amplifier which can be supplied from the ordinary 110-volt alternating current lighting mains is of considerable practical importance, since it eliminates the great practical difficulty of maintaining storage cells. The amplifier using such alternating current supply has the important advantages of reliability, convenience, and cheapness both in first cost and operating cost.

The invention will be more clearly understood by reference to the following specification and the accompanying drawings in which:

Figure 1 is a schematic wiring diagram of a complete receiver embodying two stages of radio frequency amplification, a crystal detector, and two stages of audio frequency amplification; and Fig. 2 is a wiring diagram of a modified form of our receiver including three stages of radio frequency amplification, a crystal detector, and one stage of audio frequency amplification.

It will be understood that the principles of our invention may be embodied in various forms and that details are not material. The present embodiment of the invention, therefore, is to be considered as merely indicative. The form illustrated in the drawing and hereinafter described in detail has been found to be one of the practical embodiments and capable of efficient operation and practical in construction.

The receiver of the present invention is particularly adapted for general use in receiving radio broadcasting concerts, news, lectures, music and messages. The receiver does not require the usual primary or secondary batteries as a source of power for the filament and plate circuits of the vacuum tube amplifiers. A power transformer forms a part of the apparatus and power from the standard alternating current residence lighting circuit is supplied to the primary winding of the transformer. The transformer has a plurality of secondary windings wound in such ratio as to give proportionate current and voltage values as required by the filament and plate circuits of the amplifiers. A rectifier of the two electrode valve type is employed for obtaining a direct current for the plate supply to the tubes and the filament of this valve is also supplied with heating current obtained from one of the proportionate secondary windings of the transformer. The control of the filament temperature of this valve affords means for regulating the potential supplied to the plates of the tubes.

Heretofore in the art successful results have not been obtained by employing the alternating current residence lighting circuit as a source of power supply due to the persistent and predominating interference offered in the reproducing telephones by the hum of the alternating current. We have discovered that this residual hum can be eliminated and in the present receiver the telephones are to all practical purposes absolutely silent as far as any residual hum from the alternating current power supply is concerned. To obtain this result we employ a rectifier of the crystal detector type, although other forms of rectifiers may be readily employed, interposed in circuit after the stages of radio frequency amplification and before the stages of audio frequency amplification. The use of a crystal detector is not as objectionable as it would seem on first consideration, as the radio-audio amplification in association with this form of rectifier makes possible a quick adjustment due to the fact that most any point on a sensitive crystal will bring in a signal of sufficient intensity for all practical purposes. The employment of a crystal detector in place of the electron tube detector reduced the 60-cycle hum very considerably. When an electron tube is used as the detector, there is impressed on both the plate and the filament a 60-cycle A. C. voltage which although small, becomes very objectionable when amplified by one or two stages of audio-frequency amplification. When the crystal detector is used, no 60-cycle voltage is supplied to the detector circuit. The radio-frequency transformer whose output is delivered to the detector circuit prevents the passage in any appreciable amount of 60-cycle current supplied to the radio-frequency stage and such voltages are not present in the crystal detector circuit and do not reach the input of the audio-frequency stage. In predetermined parts of the circuits of the vacuum tube amplifier voltage dividers, balancing resistances, leak resistances, condensers and choke coils are employed to balance out or neutralize any residual hum and prevents its passage into the telephone receivers.

Referring more particularly to Fig. 1 of the drawings a receiver circuit is shown adapted for connection with a variably tuned circuit and thence with an antenna ground system or with a coil antenna. The receiver illustrated comprises an amplifier circuit with two radio frequency stages, a crystal detector and two audio frequency stages. The filaments of all the tubes are connected in parallel and are lighted by alternating current voltage supplied from the secondary winding 25 of the transformer 24, their brilliancy being controlled by the rheostat 19. The primary winding of transformer 24 is shown at 28, the alternating current power supply being connected to the terminals 31 and 32.

Winding 26 of transformer 24 supplies high voltage alternating current which is rectified by the electron tube 21, smoothed out by choke coil 22 and condensers 20 and 22^a, which are about 2 microfarads capacity. The choke coil 40 may be used as a voltage limiting device in the plate circuit which serves to hold the plate voltage at the proper value regardless of the brilliancy of the electrodes of rectifier tube 21. This provides a high voltage direct current which is suitable for the plates of the amplifier tubes. The filament of the rectifier tube 21 is lighted from winding 27 of transformer 24. The rheostat 23 varies the brilliancy of the rectifier filament, which in turn controls the direct current voltage output.

The input terminals to the amplifier are shown at 1 and 2, being connected to the grid of tube 3 and terminal 2 being connected to the slider of balancing resistance 17 through a grid leak and shunting condenser indicated as a unit at 29, the latter serving to keep the grids of tubes 3 and 5 at the proper operating voltage, making the tube more suitable for amplifying. In the unit 29 the condenser is about 1 microfarad capacity and the shunting resistance is about 1 megohm. The balancing resistance 17 is about 200 ohms and is connected directly across the filament line and serves to stabilize the normal grid voltage. A similar balancing resistance 18 performs a similar function for the grids of tubes 13 and 37. The slider of balancing resistance 18 is connected through a dry battery 35 to grid of tubes 13 and 37. This battery impresses a suitable negative voltage on the grids making the tubes more suitable for amplifying. As this battery furnishes grid voltage only the power consumed is negligible. It is therefore of the small flashlight battery type and will continue effective for a period equivalent to its normal shelf life.

The plate circuit of tube 3 is coupled to the grid circuit of tube 5 by means of the radio frequency transformer 4. There is some variation in the plate current of tube 3 due to the periodic variation in filament temperature but the resultant audio frequency hum does not pass through the radio frequency coupling of transformer 4 and does not reach the input of tube 5.

The secondary of radio transformer 4 is connected to grid of tube 5 and to slider of balancing resistance 17 through condenser and shunting grid leak resistance 29, the resistance 17 keeping the grid voltage steady and the condenser and shunted resistance 29 keeping the grids at the proper negative voltage for amplifying purposes.

The primary winding of radio frequency transformer 6 is connected in the plate circuit of tube 5. The secondary winding of transformer 6 is connected to the crystal detector circuit 9 and includes the primary of audio frequency transformer 11 having a radio frequency by-pass condenser 10 shunted across the winding. The end of primary winding of transformer 11 which is connected to the crystal detector 9 is also connected to the filament circuit through a suitable condenser 9^a of 1 microfarad capacity, this condenser serving to further remove the 60 cycle hum from the telephone receivers. The secondary terminals of this audio transformer 11 are connected to the grid of tube 13 and to slider of balancing resistance 18 through battery 35. Another audio frequency stage is added in a similar manner and is indicated by transformer 36 and tube 37. The telephone receivers 14 may be connected inductively to the plate circuit of tube 37 by means of telephone transformer 33 which has a one to one ratio of windings.

By adjusting the balancing rheostats 17 and 18 the voltage of all the grids may be kept at a steady value and the battery 35 provides the proper negative voltage to the grids of the audio amplifying tubes for the best amplification, while grid leak and condenser 29 serve to keep the grids of tubes 3 and 5 at the best operating voltage.

Fig. 2 shows a modified form of circuit comprising three stages of radio frequency amplification, a crystal detector, and one stage of audio frequency amplification. As in the former case the slider of balancing resistance 17 is connected through a condenser shunted by a leak resistance 29 to the grids of the radio frequency amplifying tubes. The capacity of this condenser is about one microfarad. With this condenser in the circuit as shown, the grids assume a normal voltage suitable for amplifying as derived from winding 25 of transformer 24 while the balancing resistance 17 neutralizes effect of the alternating current on the filaments. The leak resistance across condenser 29 permits any super-charge on the grids to leak off to the filaments. This connection of condenser, high resistance leak and rheostat forms one of the neutralizing means for eliminating the hum of the alternating current from the reproducing telephone receivers.

The grid circuit of the audio frequency amplifier tube 13 is connected to the slider of balancing resistance 18 through condenser and shunted leak 12, which replaces the grid battery 35 used in the former circuit. The condenser 12 is about .02 microfarads capacity.

The purpose of the condenser 12 is to allow the grid of tube 13 to assume a normal voltage suitable for amplifying while the balancing resistance 18 serves to keep the grid voltage steady with respect to the filaments. This forms another of the means for eliminating the alternating current hum from the reproducing telephone receivers.

In series with the plate circuit of tube 13 is a condenser 15 of about .02 microfarads capacity shunted by resistance 16 of about 80,000 ohms. The action of this condenser and resistance is to partially block the low frequency fluctuations in plate current, caused by the periodic change in filament temperature, while the higher frequencies pass through more easily. The 80,000 ohms resistance allows the high voltage direct current to flow to the plate. In the secondary circuit of the telephone transformer 33 and in series with the telephone receivers 14 is shown a condenser 34 of about .02 microfarads capacity which partially blocks any low frequency hum from flowing into the telephone circuit, but which allows the higher frequencies to pass through more easily. The source of filament current and plate voltage is obtained from transformer 24 and two electrode tube rectifier 21 in the manner as described in the circuit arrangement of Fig. 1.

In either of these circuits, instead of the balancing resistance across the filament line, a divided condenser circuit with suitable grid leaks shunted across the condensers may be provided and a connection taken from the center thereof to the grid circuit, or the filament current winding on the transformer may be tapped at its electrical center and lead to the grid circuit. By provision of these neutralizers and the crystal detector rectifier the operator wearing head telephone receivers 14 has no practical interference from the low frequency hum of the alternating current power supply.

The amplifier as above described is adapted to be mounted in a readily portable cabinet which may also contain suitable variable tuning apparatus and the coil aerial, thus making a complete compact, portable, and practical receiving unit. The power transformer is provided with a flexible cord lead and this may be plugged in to a source of standard house lighting current such as 110 volts 60 cycles A. C. The filaments of the tubes are brought up to an electron emitting temperature by rheostat 19. The plate potential is regulated by varying the temperature of the filament of the rectifier tube 21 by varying the rheostat 23. Rheostats 17 and 18 are regulated to adjust the grid potential and secure neutralization of any disturbing interference from low frequency hum. The crystal detector is adjusted to maximum sensitivity and the radio telephone or telegraph signals reproduced in telephone receivers 14.

While we have described our invention in certain specific embodiments, it will be understood that modifications may be made and that no limitations upon the invention are intended beyond the scope of the appended claims.

What we claim is:

1. In an apparatus for receiving radio signals the combination of a source of signal energy, means for amplifying said energy, means for rectifying said energy, and a source of alternating current for supplying power to said amplifying means and a plurality of means in circuit with said amplifying means for eliminating the hum of said alternating current in said apparatus.

2. In an apparatus for the reception of radio signals the combination of a source of signal energy, means for amplifying said signals, means for rectifying said signals, a source of alternating current for supplying power to said amplifying means, and means connected to said amplifying and rectifying means for eliminating the hum of said alternating current in said apparatus.

3. In an apparatus for the reception of radio signals the combination of a source of signal energy, means for amplifying said signal energy at radio frequencies, means for rectifying said energy, means for amplifying said energy at audio frequencies, a source of alternating current for supplying power to said amplifying means and separate means connected to each of said amplifying and rectifying means for eliminating the hum of said alternating current in said apparatus.

4. In an apparatus for the reception of radio signals the combination of a source of signal energy, means for amplifying said energy at radio frequencies, means for rectifying said energy, means for amplifying said energy at audio frequencies, a reproducer connected to said last amplifying means, a source of alternating current for supplying power to said amplifying means, and means connected to each of said amplifying, rectifying and reproducing means for eliminating the hum of the alternating current in said apparatus.

5. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes arranged to amplify said energy at radio frequencies, a crystal detector arranged to rectify said energy, means for amplifying and reproducing said energy at audio frequencies, a source of alternating current for supplying power to said amplifying means, and a plurality of means for eliminating the hum of said alternating current in said apparatus.

6. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes having grid, filament and plate electrodes, circuits interconnecting said electrodes whereby said tubes amplify said signal energy at radio frequencies, a crystal detector for rectifying said energy, means for amplifying and reproducing said energy at audio frequencies, a source of alternating current for supplying power to said amplifying means, and means in each of said circuits for eliminating the hum of the alternating current in said apparatus.

7. In an apparatus for the reception of radio signals the combination of a source of signal energy, means for amplifying said energy at radio frequencies, means for rectifying said energy, means for amplifying and reproducing said energy at audio frequencies, a source of alternating current, means for rectifying said current and supplying the rectified power to the circuits of said amplifying means and separate means in different parts of said circuits for eliminating the hum of the alternating current in said apparatus.

8. In an apparatus for the reception of radio signals the combination of a source of signal energy, a radio frequency vacuum tube amplifier, a crystal detector, an audio frequency vacuum tube amplifier, circuits connecting said amplifiers with said crystal detector, a source of alternating current for supplying power to said amplifiers, and separate means in each of said circuits for eliminating the hum of the alternating current in said apparatus.

9. In an apparatus for the reception of radio signals the combination of a source of signal energy, a radio frequency vacuum tube amplifier, a crystal detector, an audio frequency vacuum tube amplifier, circuits connecting said amplifiers with said crystal detector, a source of alternating current for supplying power to said amplifiers, adjustable means in said amplifier circuits and fixed means connected to said detector circuit for eliminating the hum of said alternating current in said apparatus.

10. In an apparatus for the reception of radio signals the combination of a source of signal energy, a radio frequency vacuum tube amplifier, a crystal detector, an audio frequency vacuum tube amplifier means for reproducing the signal energy, circuits connecting said amplifiers with said crystal detector, a source of alternating current for supplying power to said amplifiers, condensers shunted by resistances connected in said amplifier circuits, and adjustable means for eliminating the hum of said alternating current in said reproducing means.

11. In an apparatus for the reception of radio signals the combination of a source of signal energy, a radio frequency vacuum tube amplifier, a crystal detector, an audio frequency vacuum tube amplifier, a reproducer connected to said audio frequency amplifier, a transformer having a primary winding and a plurality of secondary windings, a source of alternating current connected to said primary winding, said secondary windings being connected to supply power to the circuits of said vacuum tube amplifiers, and hum eliminators connected in different portions of said circuits.

12. In an apparatus for the reception of radio signals the combination of a source of signal energy, a radio frequency vacuum tube amplifier, a crystal detector, an audio frequency vacuum tube amplifier, a reproducer connected to said audio frequency amplifier, a transformer having a primary winding and a plurality of secondary windings, a source of alternating current connected to said primary winding, said secondary windings being connected to supply power to the circuits of said vacuum tube amplifiers, and separate means connected in each of the circuits of said amplifiers, detector and reproducer for eliminating the hum of said alternating current in said apparatus.

13. In an apparatus for the reception of radio signals the combination of a source of signal energy, a radio frequency vacuum tube amplifier, a detector, an audio frequency vacuum tube amplifier, a reproducer connected to said audio frequency amplifier, a transformer having a primary winding and a plurality of secondary windings, a source of alternating current connected to said primary winding, means for rectifying energy from one of said secondary windings, means for supplying the rectified energy to the circuits of said vacuum tube amplifiers, and separate means connected in each of the circuits of said amplifiers, detector and reproducer for eliminating the hum of said alternating current in said apparatus.

14. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes having grid, filament and plate electrodes, circuits interconnecting said electrodes whereby said tubes amplify said signal energy at radio frequencies, a detector for rectifying said energy, vacuum tubes for amplifying said energy at audio frequencies, a source of alternating current, means for supplying said current to the filaments of said tubes, means for rectifying said current and supplying potential to the plate circuits of said tubes, and separate means in each of said circuits for eliminating the hum of the alternating current in said apparatus.

15. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes having grid, filament and plate electrodes, a detector, circuits interconnecting said electrodes and said detector, a transformer having a primary winding connected to a source of alternating current, secondary windings, a two electrode valve rectifier having a filament and a plate, connections between one of said secondary windings and the filament of said rectifier, connections between another of said secondary windings and said rectifier whereby direct current is supplied to the plate circuits of said vacuum tubes, another of said secondary windings connected to supply heating current to the filaments of said vacuum tubes and a capacity and resistance connected in said plate circuits for eliminating the hum of said alternating current in said apparatus.

16. In an apparatus for receiving radio signals the combination of a source of signal energy, means for amplifying said energy, means for rectifying said energy, a source of alternating current for supplying power to said amplifying means, means for rectifying said current, and a plurality of separate means connected in circuit with said rectifying means for smoothing out the rectified current and supplying power to said amplifying means.

17. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes having grid, filament and plate electrodes, a source of alternating current for supplying power to said tubes, a detector for rectifying said signal energy, circuits interconnecting said electrodes and said detector, and an unipolar connection including a condenser between the circuit containing said detector and said filament electrodes, and means in said circuits for eliminating the hum of the alternating current in said apparatus.

18. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes having grid, filament and plate electrodes, a detector, circuits interconnecting said electrodes and said detector, a source of alternating current for supplying power to

said circuits, and means connected in circuit with said grid and plate electrodes for eliminating the hum of the alternating current in said apparatus.

19. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes having grid, filament and plate electrodes, a detector, circuits interconnecting said electrodes and said detector, a source of alternating current, a two electrode valve for rectifying said current and supplying the rectified energy to the plate electrodes of said vacuum tubes, and means connected in circuit with said plate electrodes for limiting the potential supplied to said plate circuits from said two electrode valve.

20. In an apparatus for receiving radio signals the combination of a source of signal energy, means for amplifying said energy, means for rectifying said energy, means for reproducing said energy, a source of alternating current for supplying power to said amplifying means, and means connected in circuit with said reproducing means for eliminating the hum of said alternating current in the reproducing means.

21. In an apparatus for the reception of radio signals the combination of a source of signal energy, a plurality of vacuum tubes having grid, filament and plate electrodes, a source of alternating current for supplying power to said tubes, a detector for rectifying said signal energy, circuits interconnecting said electrodes and said detector, fixed means in circuit with said grid electrodes and said plate electrodes, and variable means in circuit with said grid electrodes, all of said means serving to eliminate the hum of the alternating current in said apparatus.

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